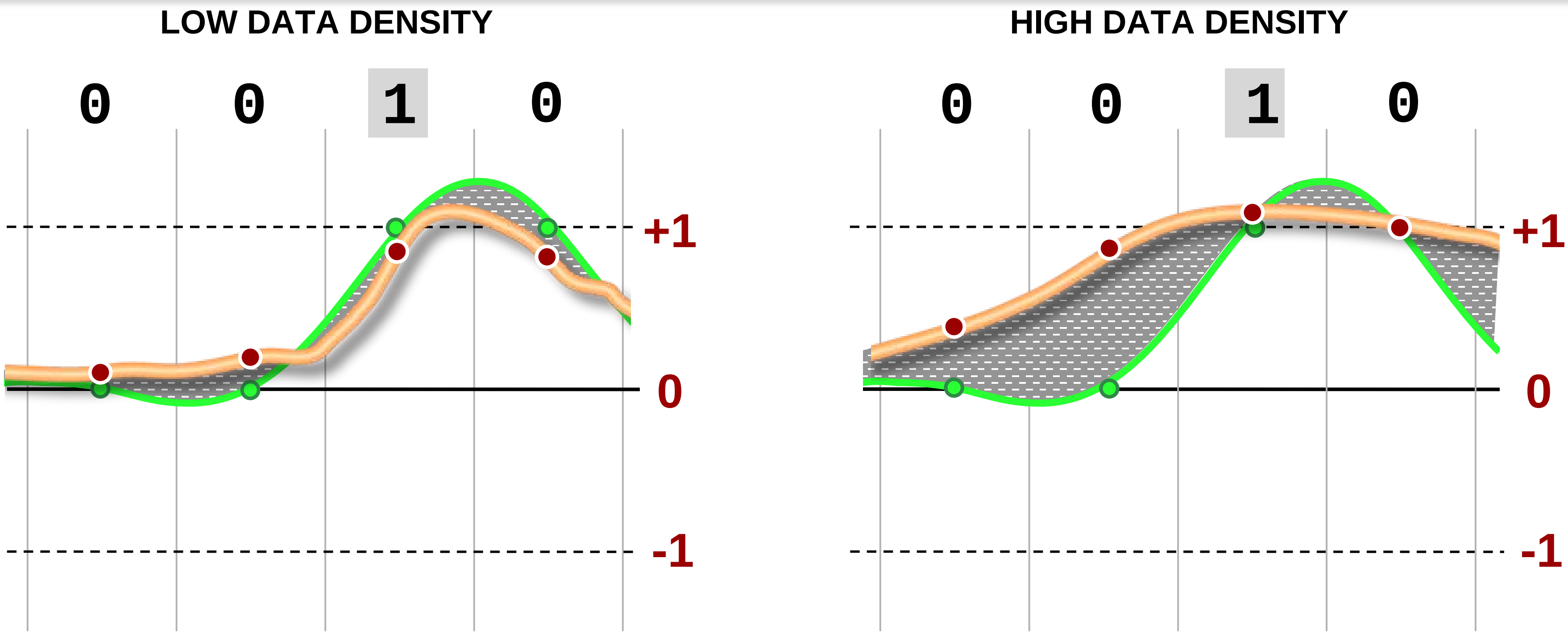
Exhibit A

Part 4

The Impact of the Noise Increases in High-Density Environments

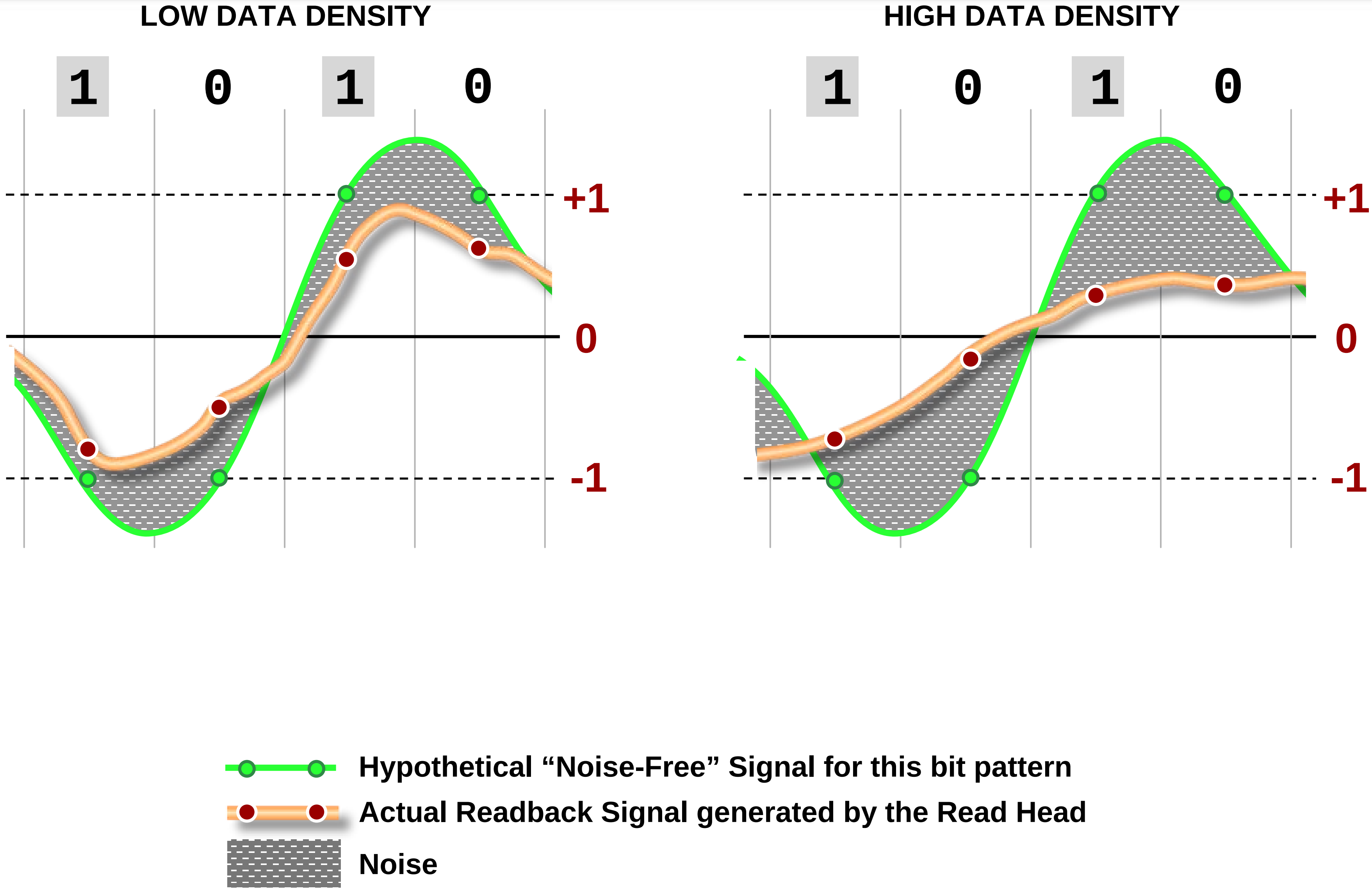


Hypothetical "Noise-Free" Signal for this bit pattern

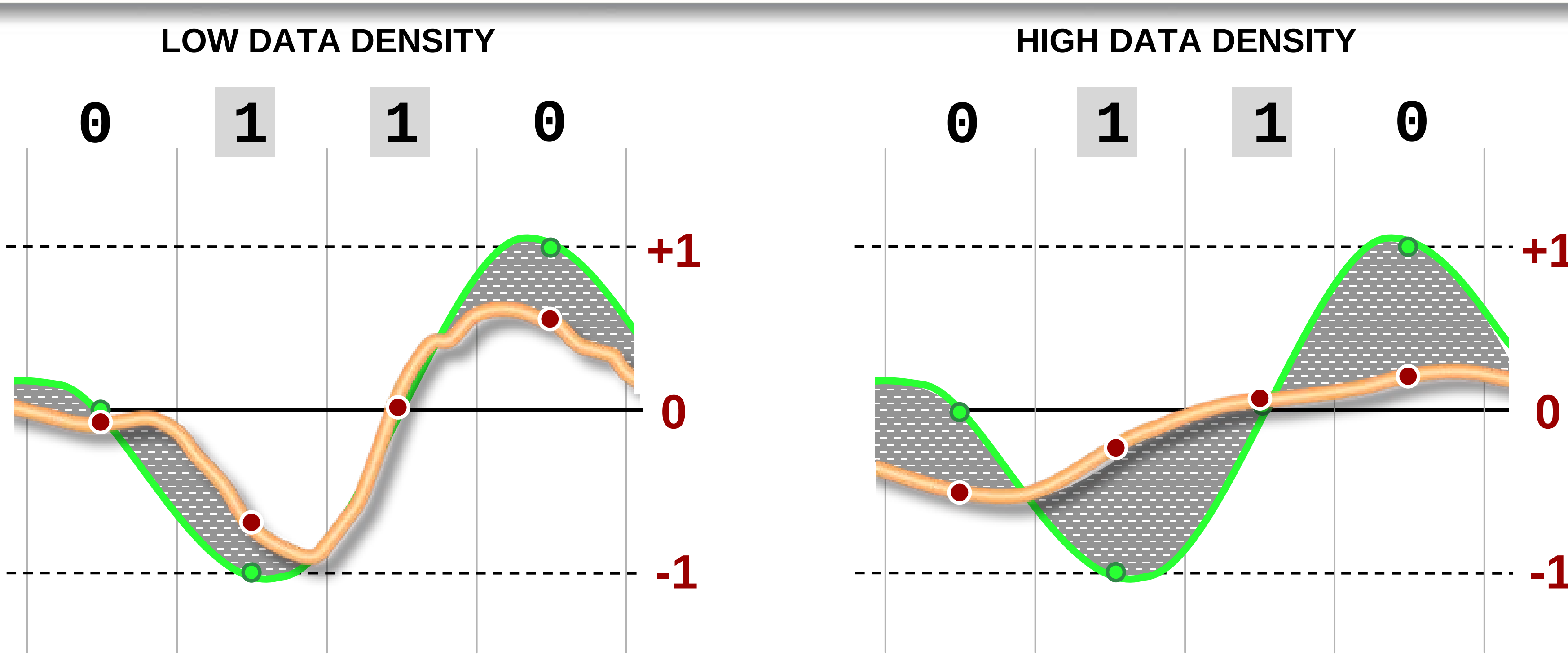
Actual Readback Signal generated by the Read Head

Noise

The Impact of the Noise Increases in High-Density Environments



The Impact of the Noise Increases in High-Density Environments

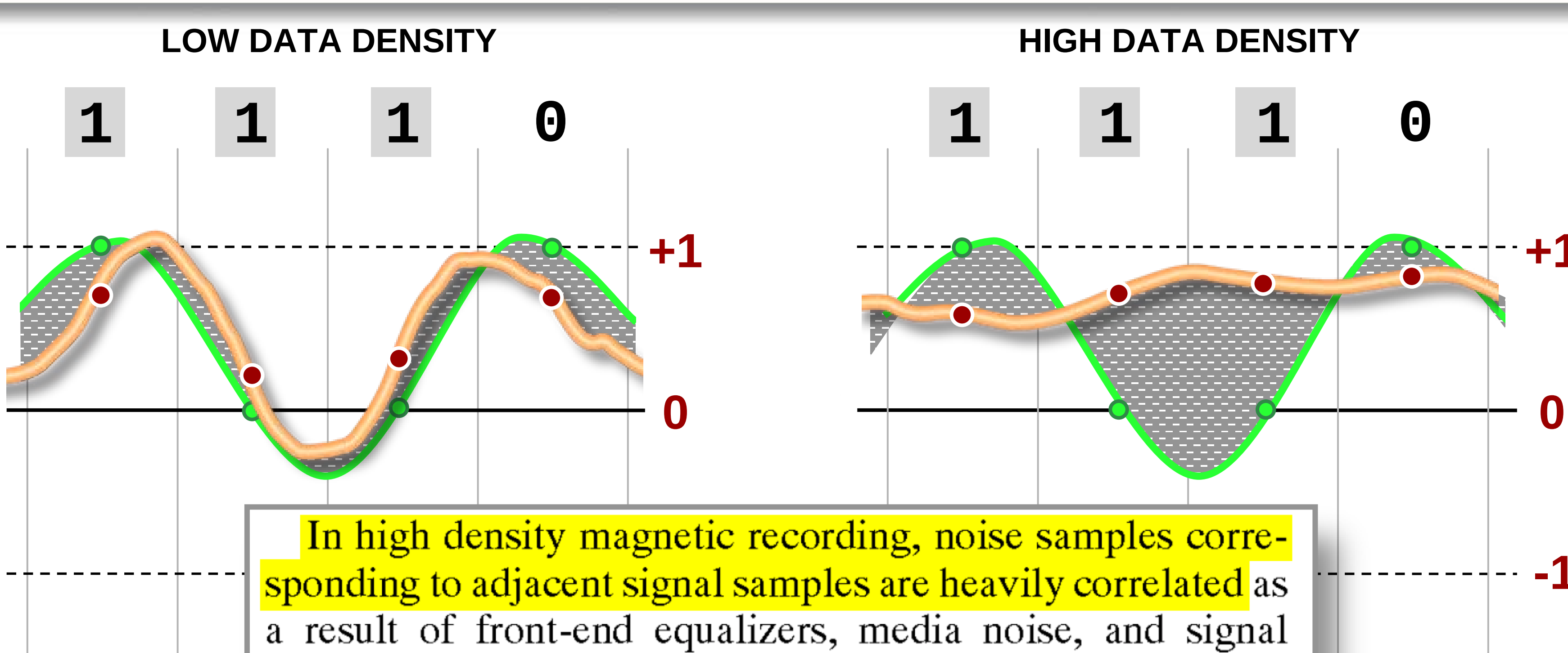


Hypothetical “Noise-Free” Signal for this bit pattern

Actual Readback Signal generated by the Read Head

Noise

The Impact of the Noise Increases in High-Density Environments



> In high density magnetic recording, noise samples corresponding to adjacent signal samples are heavily correlated as a result of front-end equalizers, media noise, and signal nonlinearities combined with nonlinear filters to cancel them. This correlation deteriorates significantly the performance of detectors at high densities.

Hypothetical "Noise-Free" Signal for this bit pattern

Actual Readback Signal generated by the Read Head

Noise

Source: '839 Patent (2:2-7)

The Viterbi Algorithm and the "Trellis"

Peak Detectors

Any signal reading above or below a certain negative or positive threshold value is converted to a digital “1”

The Viterbi Algorithm

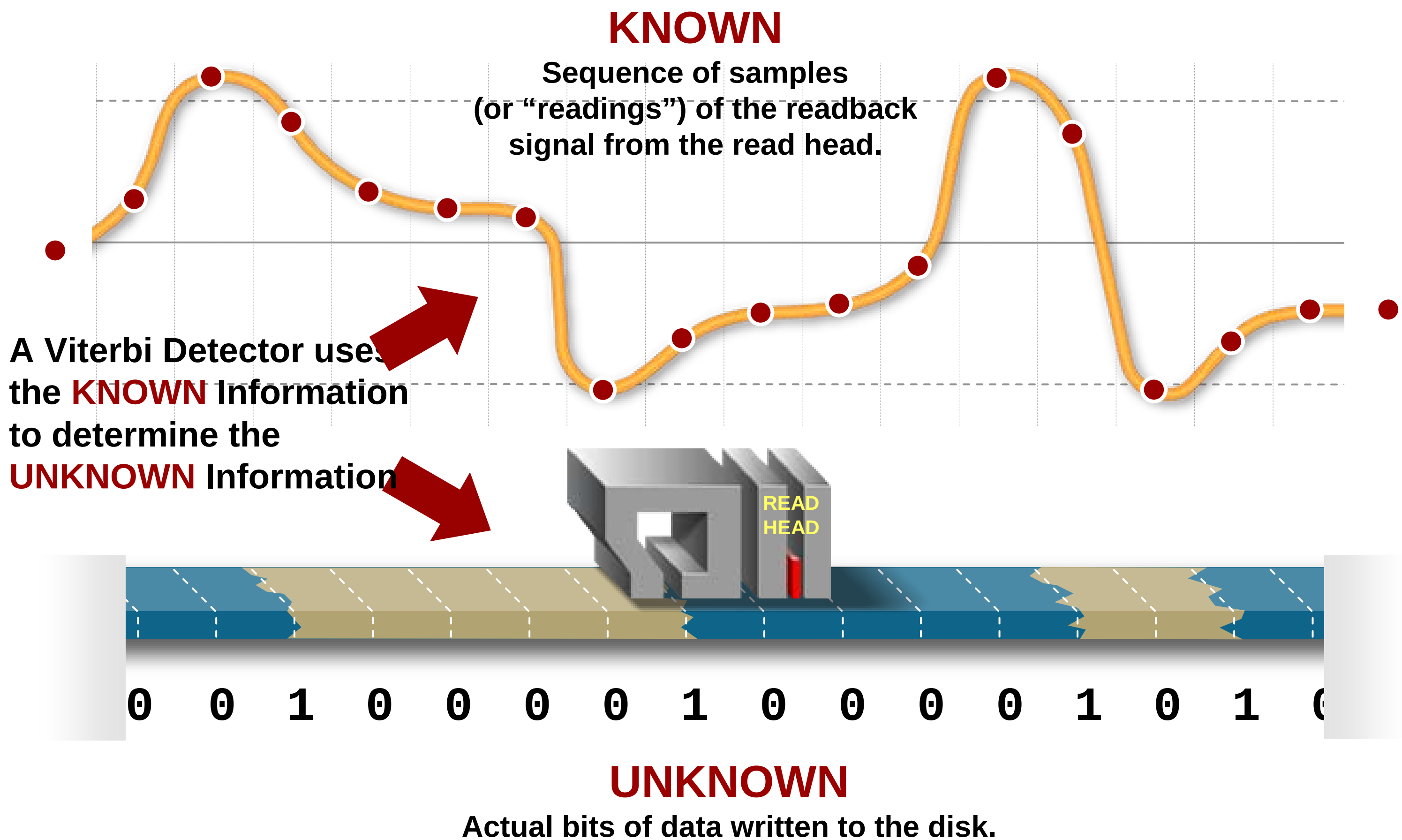
0 1 0 0 0 0 1 0 1 0 0 1 0

Conceived by Andrew Viterbi in 1967
as a decoding algorithm for noisy digital communication links
(used in cell phone signals, satellite and deep space communication, speech recognition, Wi-Fi and more)

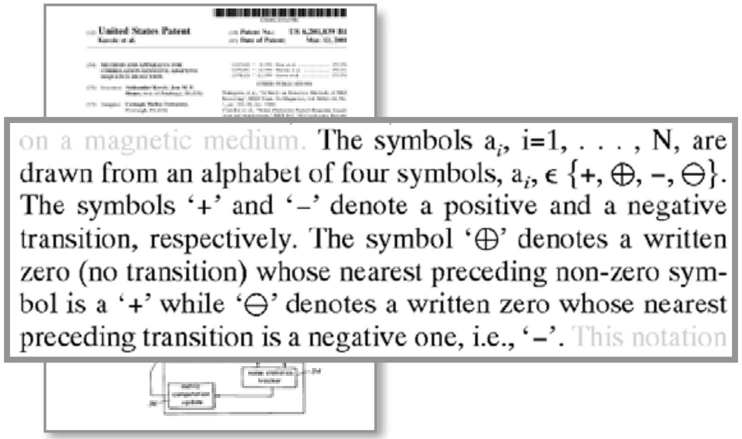
Any signal reading above or below a certain negative or positive threshold value is converted to a digital “1”

al·go·rithm: a rule (or set of rules) specifying how to solve some problem

"Known" and "Unknown" Information



Data Symbols



on a magnetic medium. The symbols a_i, i=1, . . . , N, are drawn from an alphabet of four symbols, $a_i \in \{+, \oplus, -, \ominus\}$. The symbols '+' and '–' denote a positive and a negative transition, respectively. The symbol '$\oplus$' denotes a written zero (no transition) whose nearest preceding non-zero symbol is a '+' while '$\ominus$' denotes a written zero whose nearest preceding transition is a negative one, i.e., '–'. This notation

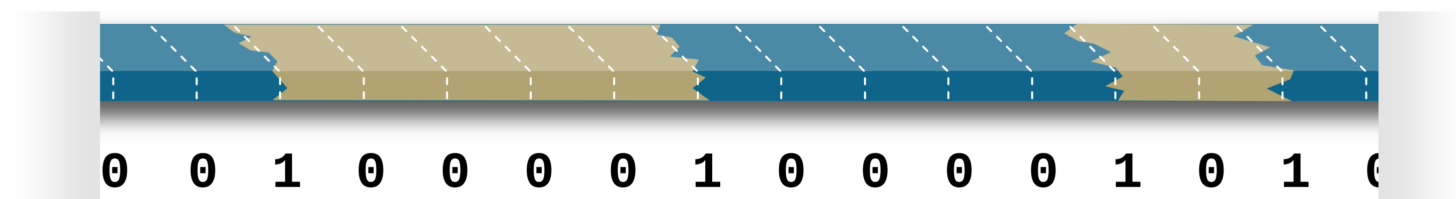
FOUR possible "states"

$+$

$\oplus$

$\ominus$

$-$

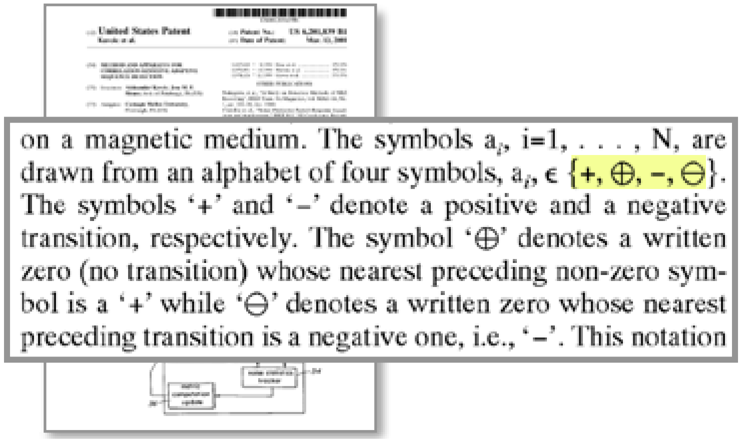


UNKNOWN

Actual bits of data written to the disk.

Source: '839 Patent
(3:54-60)

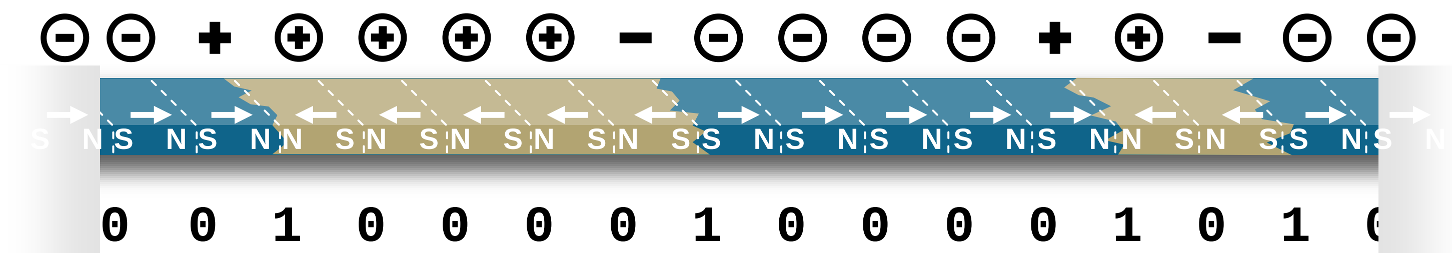
Data Symbols



on a magnetic medium. The symbols a_i, i=1, . . . , N, are drawn from an alphabet of four symbols, $a_i \in$ {+, ⊕, −, ⊖}. The symbols '+' and '−' denote a positive and a negative transition, respectively. The symbol '⊕' denotes a written zero (no transition) whose nearest preceding non-zero symbol is a '+' while '⊖' denotes a written zero whose nearest preceding transition is a negative one, i.e., '−'. This notation

FOUR possible "states"

- **+** POSITIVE transition
- **⊕** Nearest preceding transition is POSITIVE
- **⊖** Nearest preceding transition is NEGATIVE
- **−** NEGATIVE transition

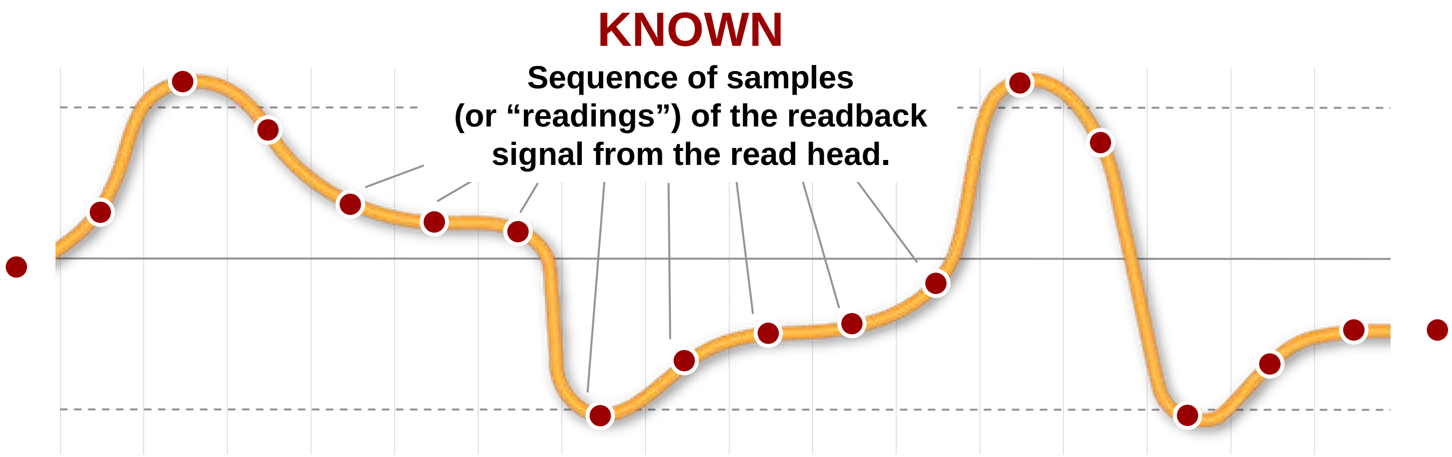


UNKNOWN

Actual bits of data written to the disk.

Source: '839 Patent (3:54-60)

Data Symbols



The Trellis

+

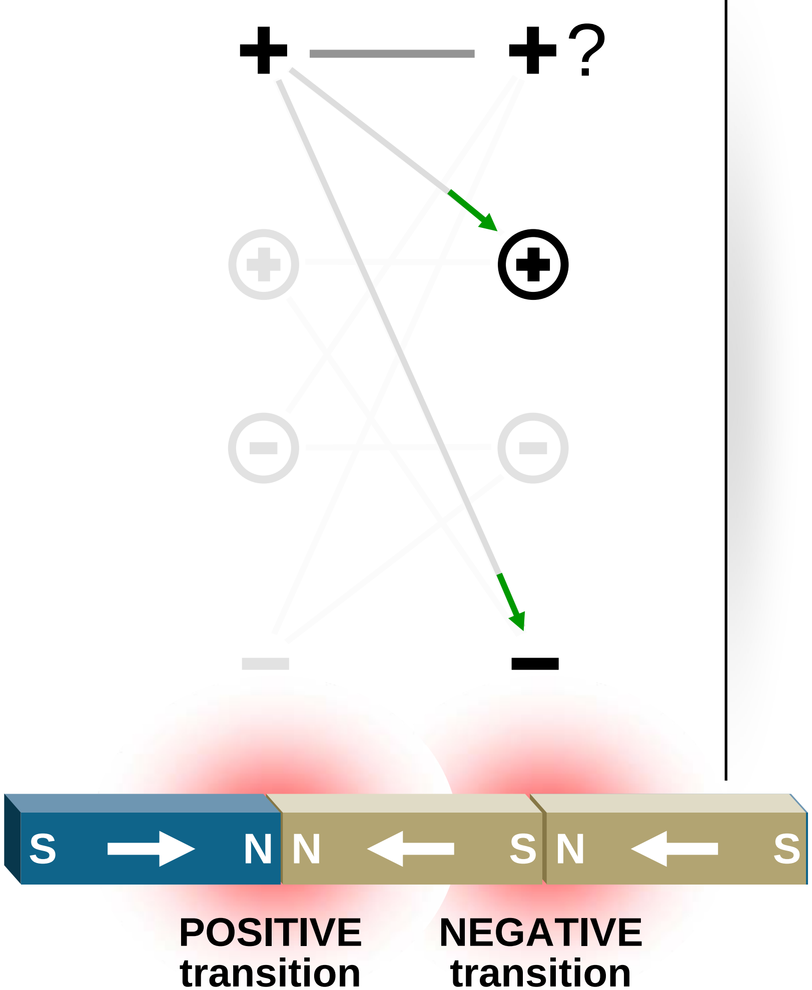
⊕

⊖

−

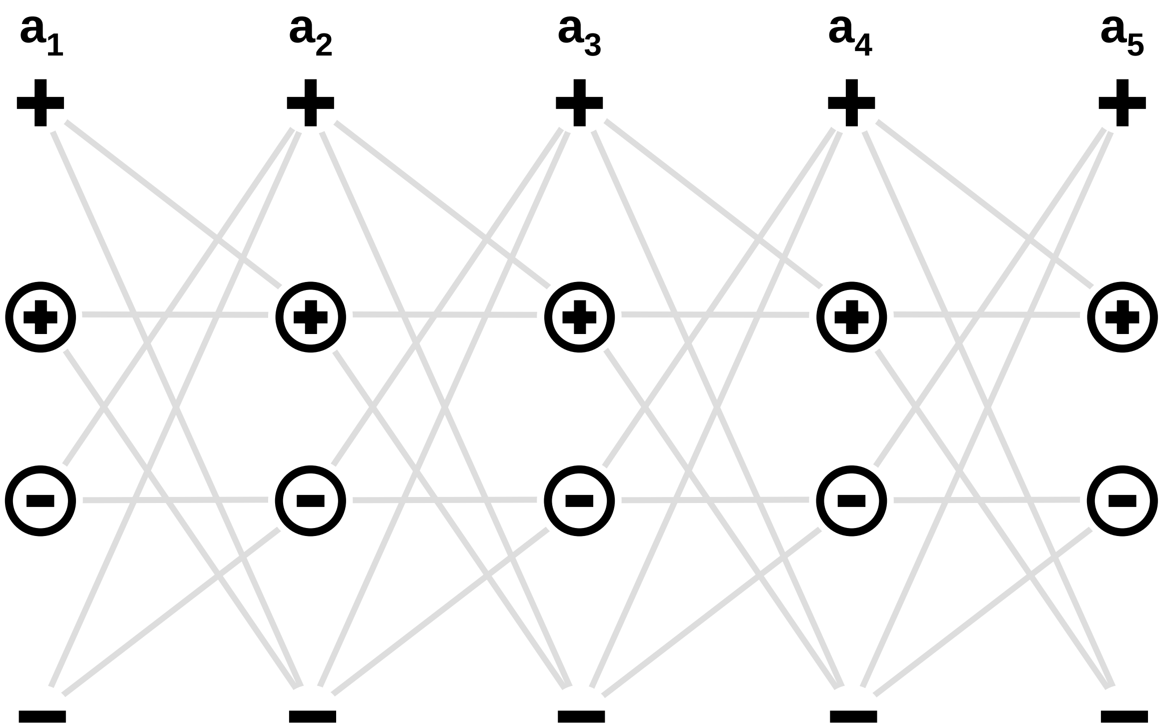
Four possible states for each symbol written on the disk (UNKNOWN information)

The Trellis



There are two possible connections (or "branches") coming from and going to each state

The Trellis



The Kavcic-Moura Patents

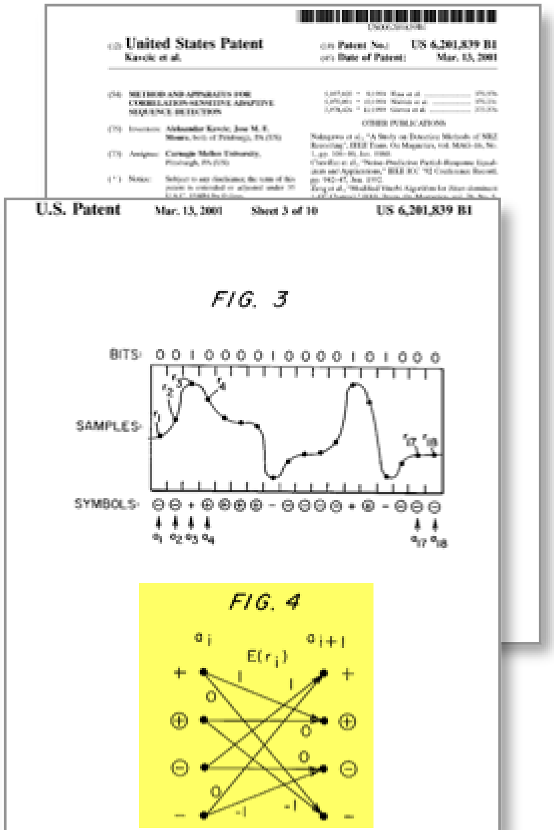
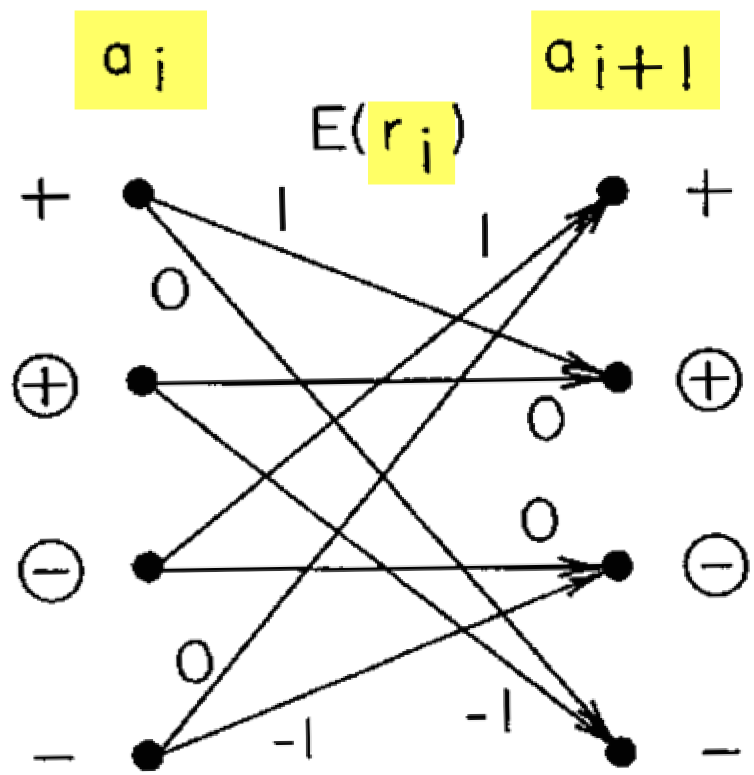
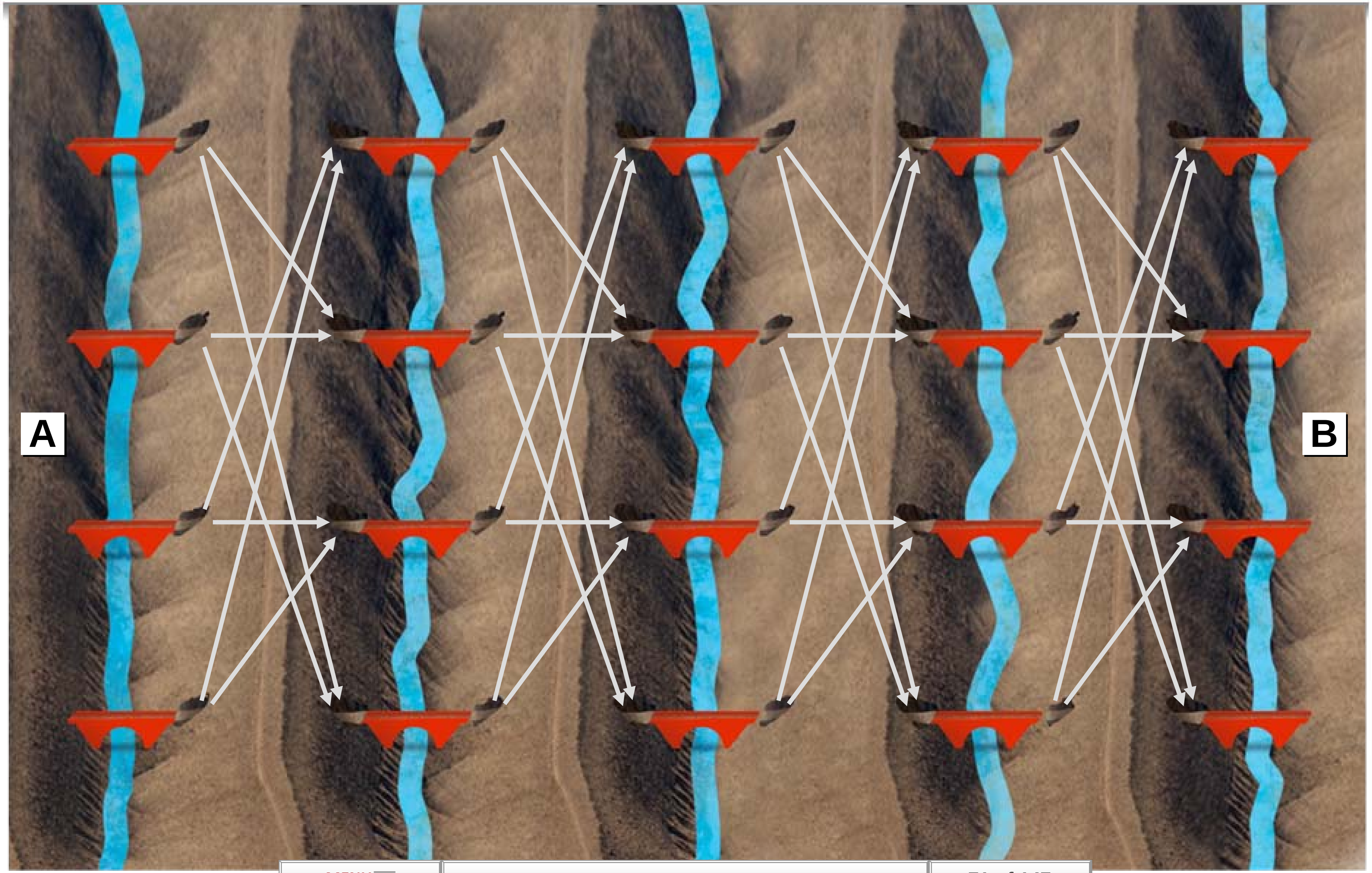


FIG. 4

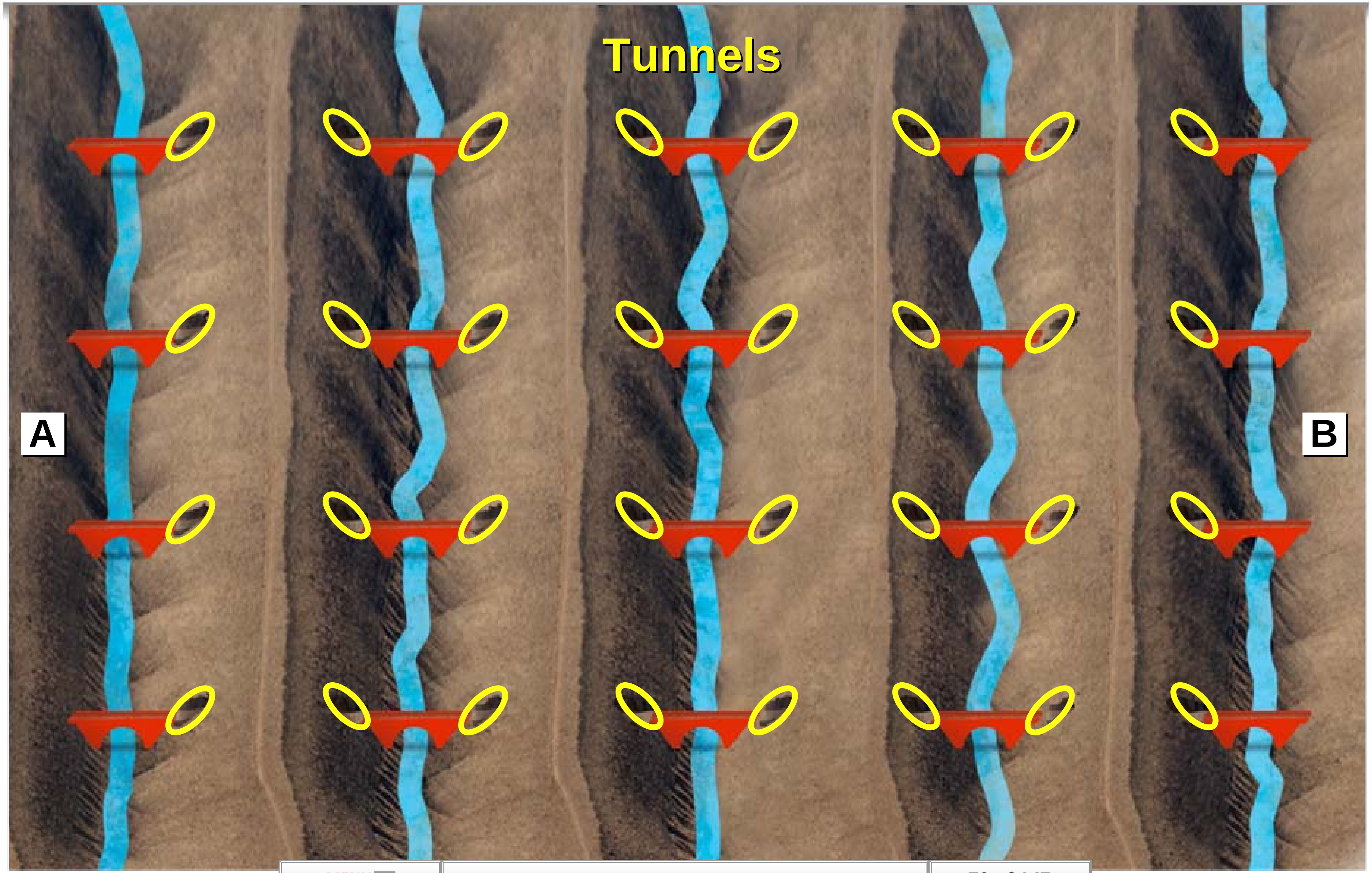


Finding the Most Likely Path from "A" to "B"



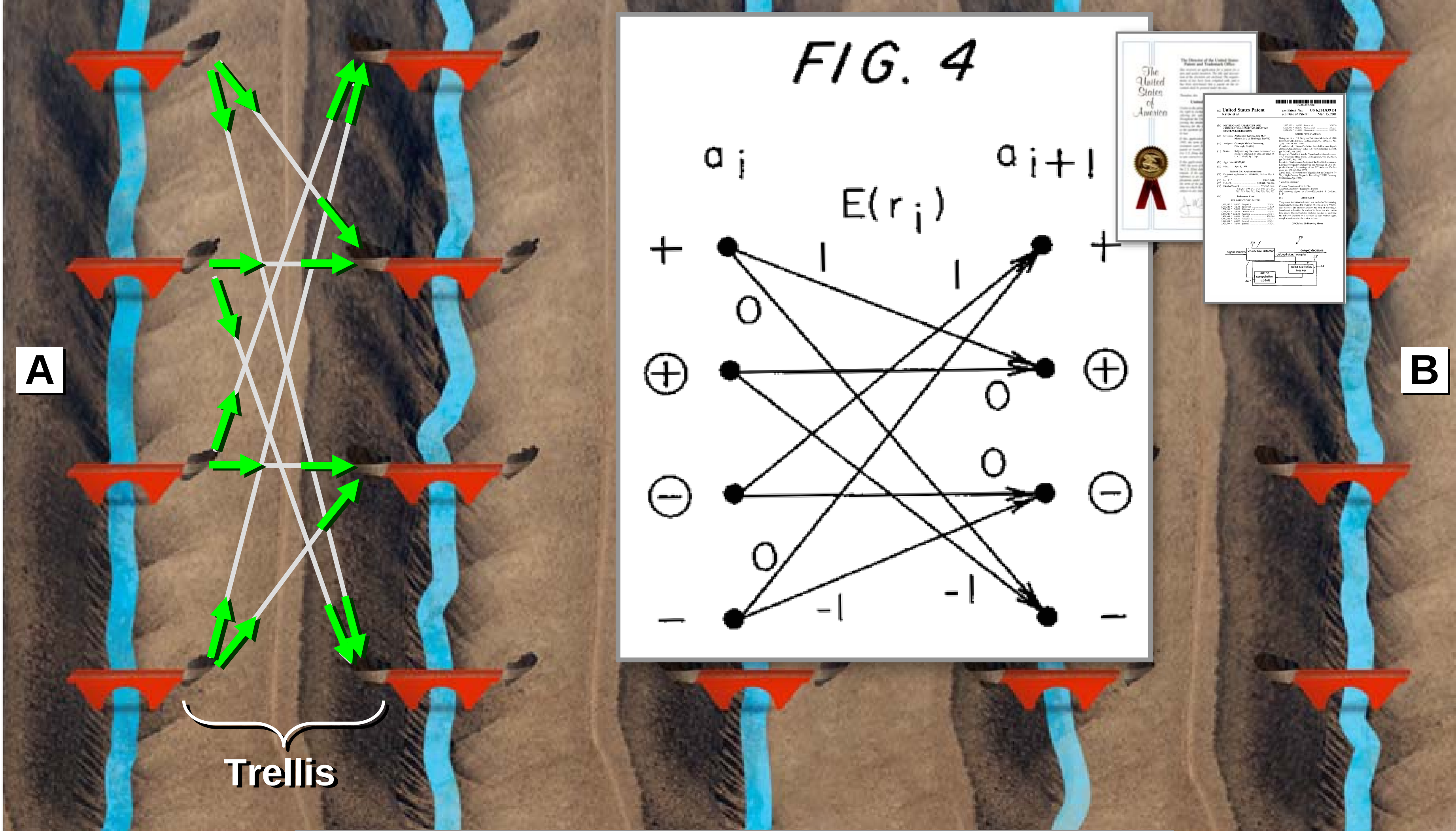
Finding the Most Likely Path from “A” to “B”

Finding the Most Likely Path from "A" to "B"

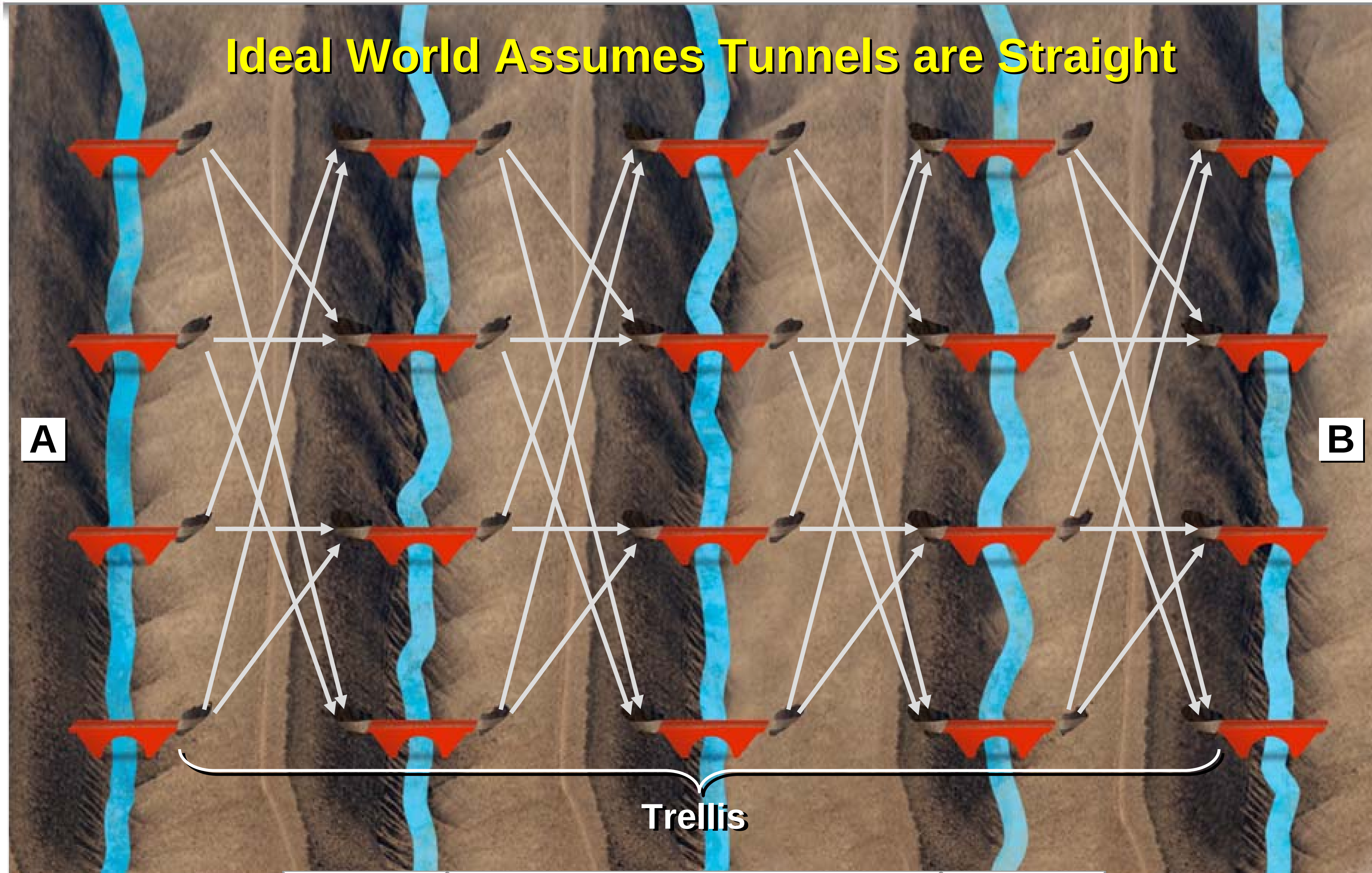


Finding the Most Likely Path from “A” to “B”

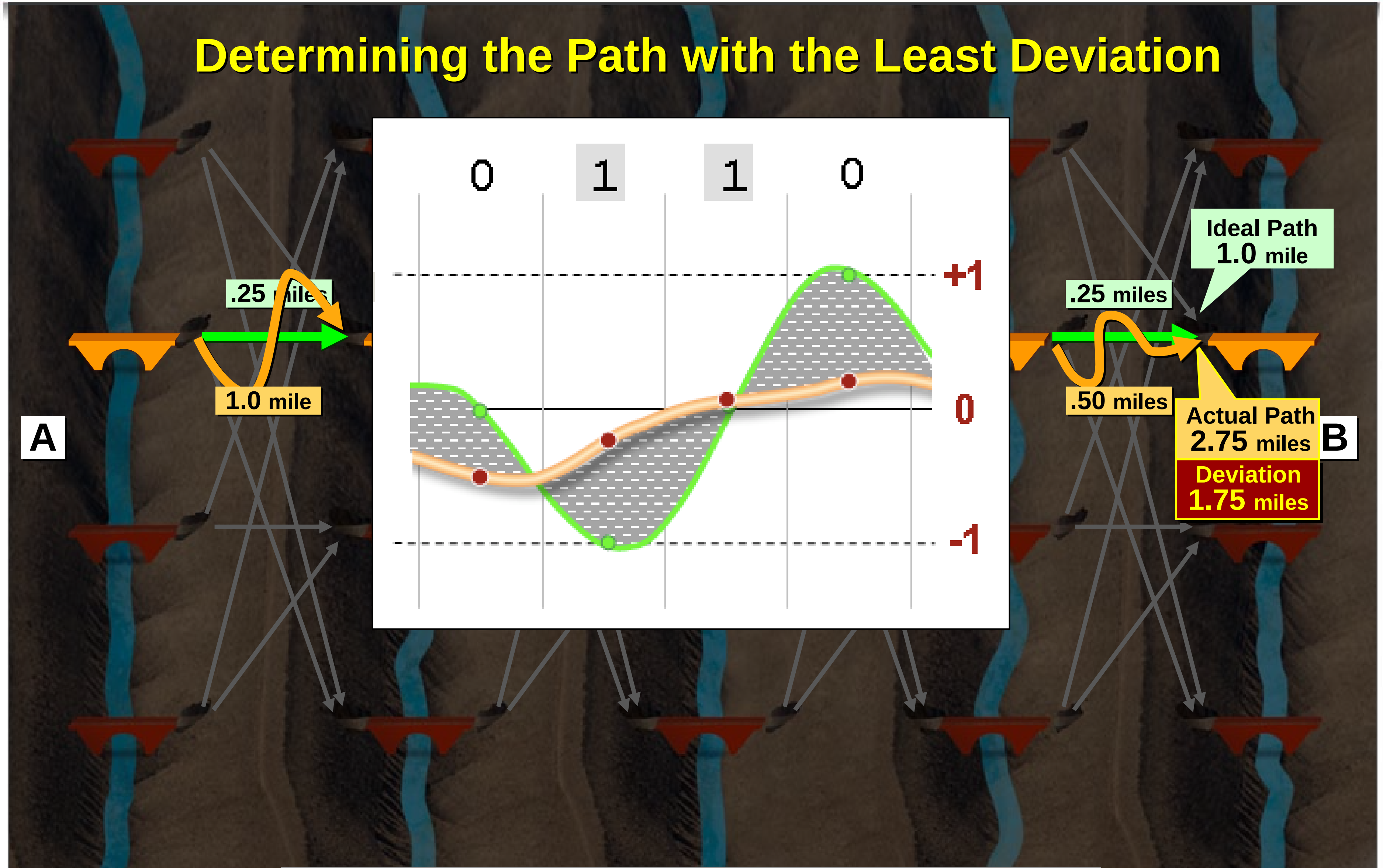
Ideal World Assumes Tunnels are Straight



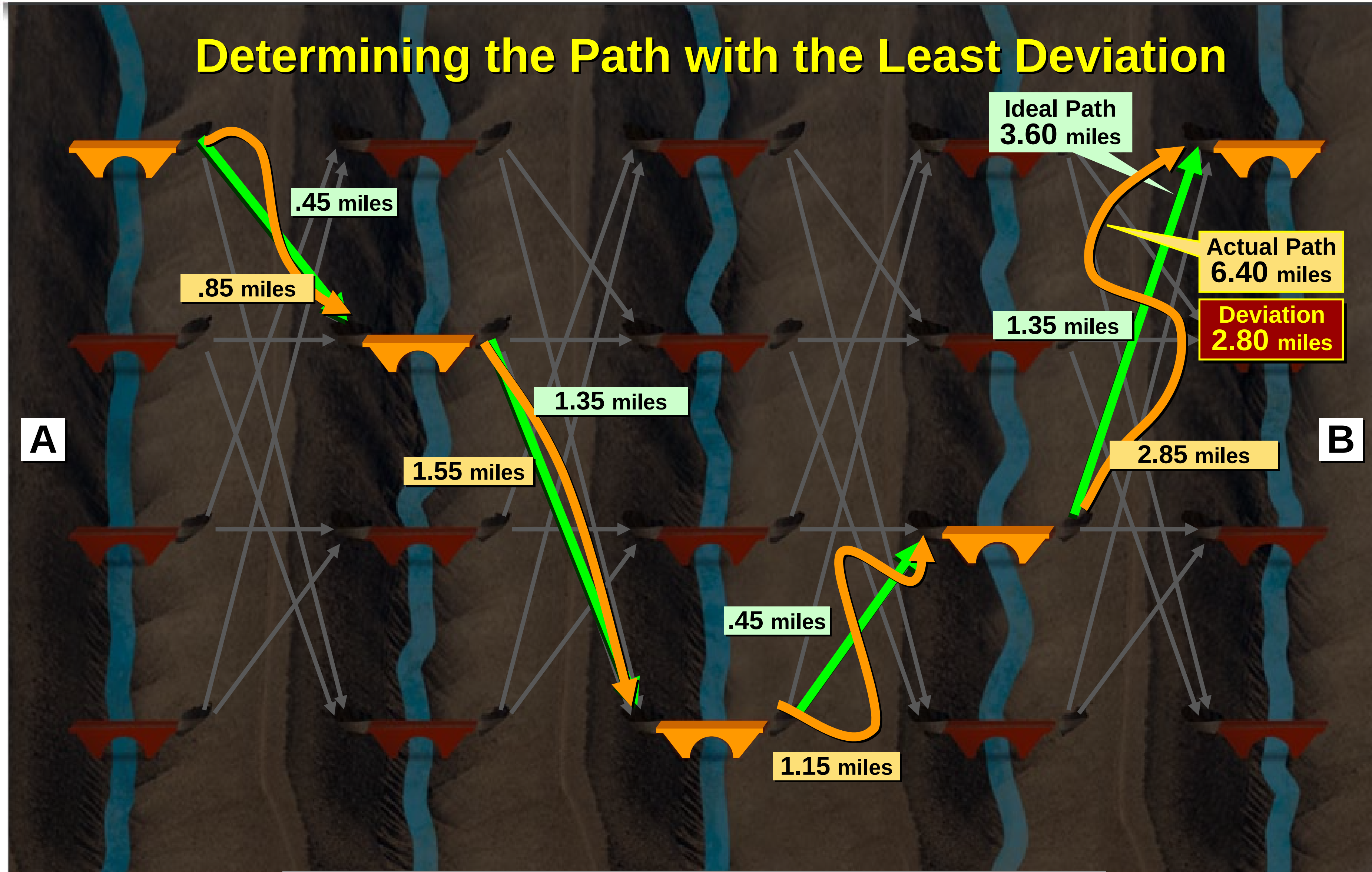
Finding the Most Likely Path from "A" to "B"



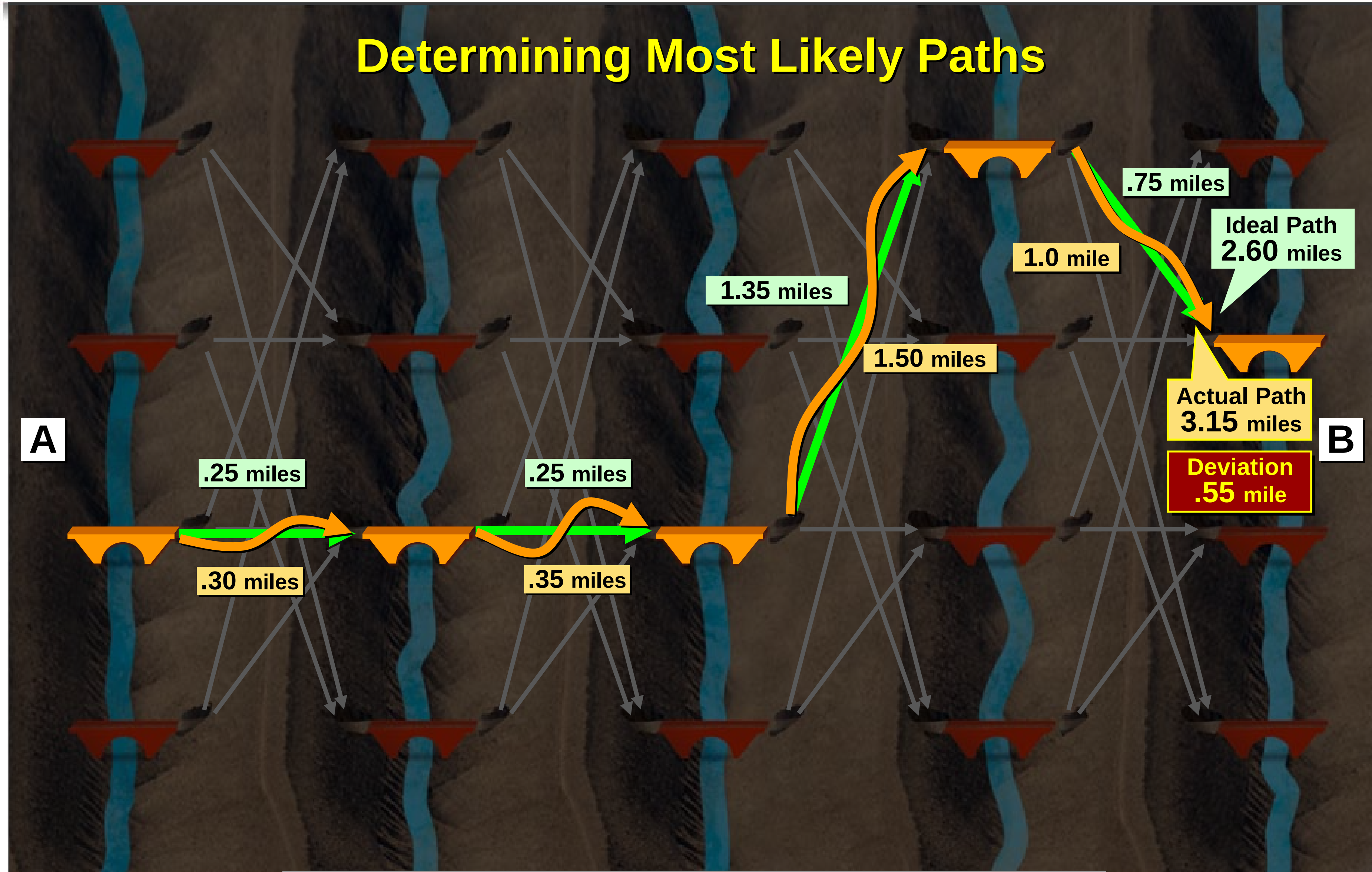
Finding the Most Likely Path from "A" to "B"



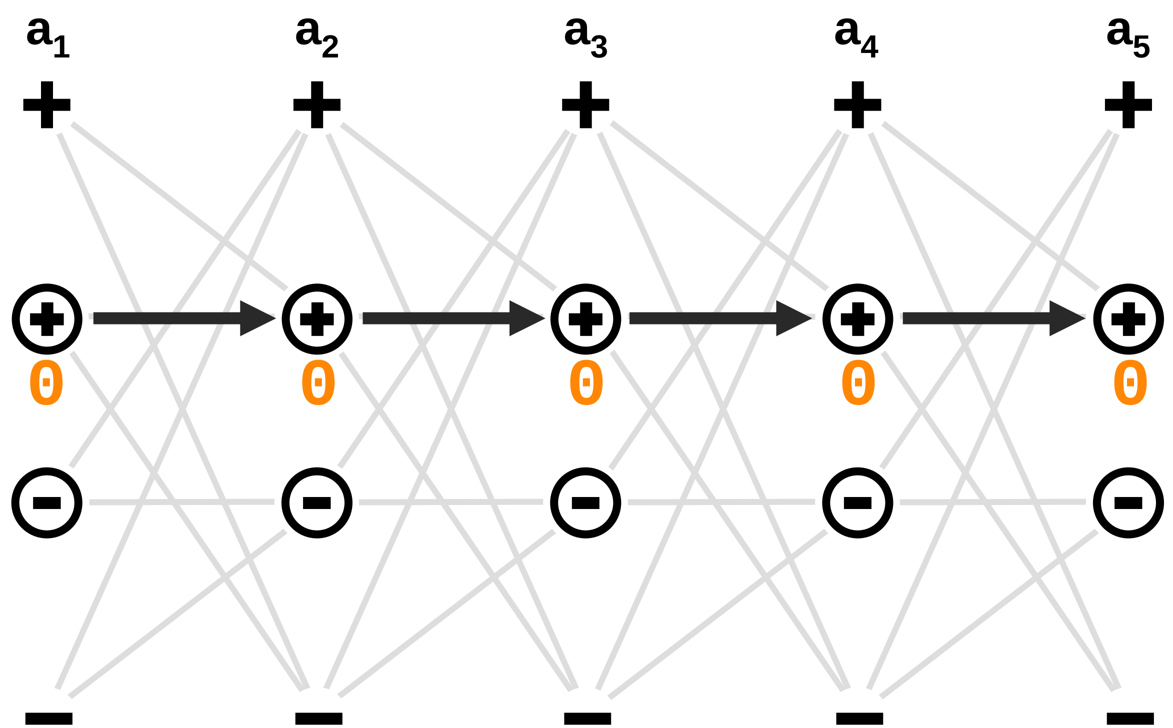
Finding the Most Likely Path from "A" to "B"



Finding the Most Likely Path from “A” to “B”

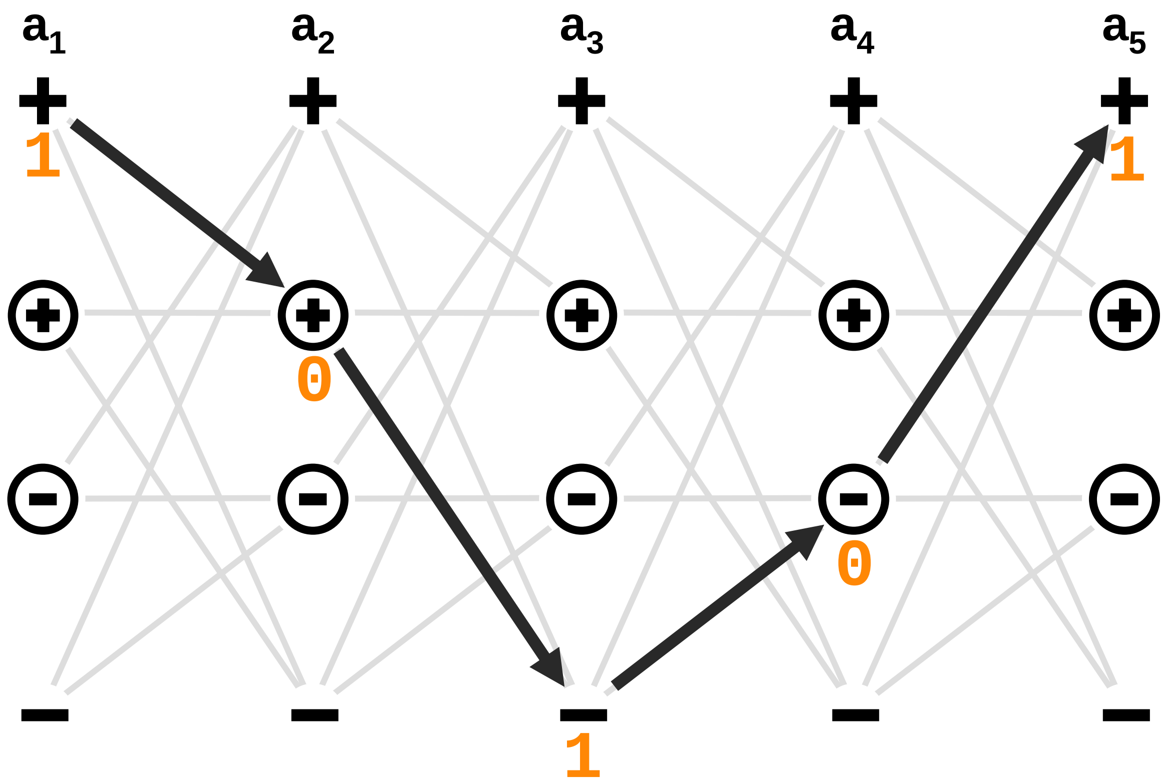


The Trellis



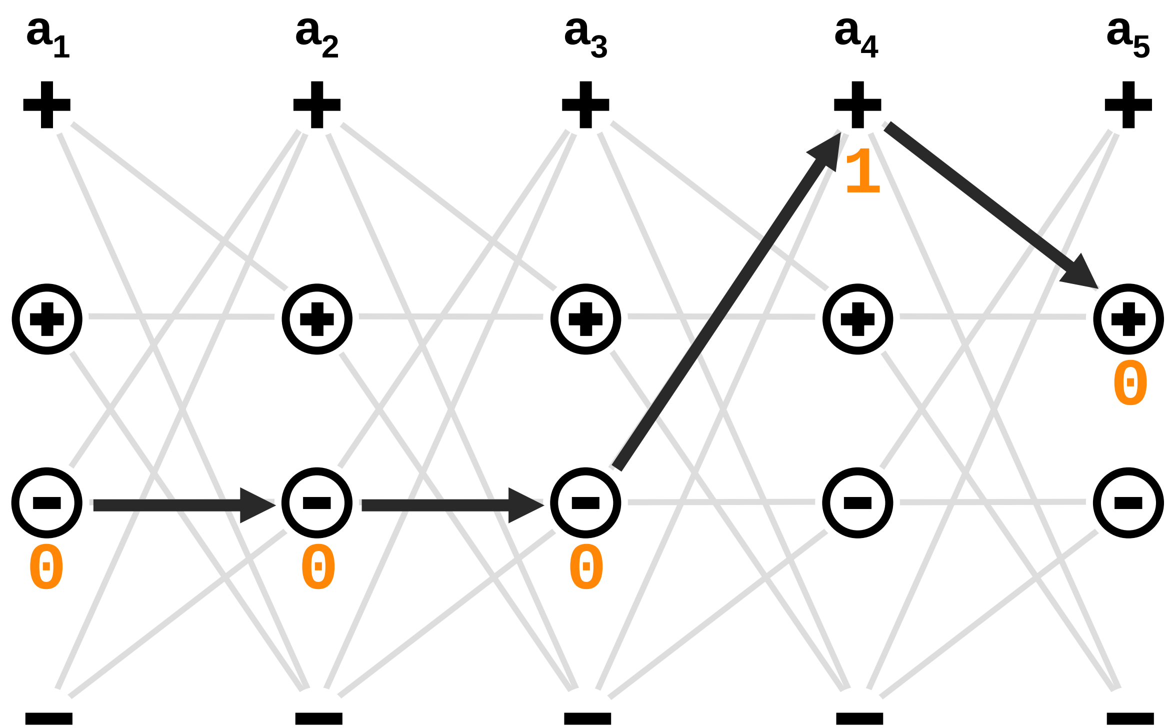
There are numerous possible paths through the trellis

The Trellis



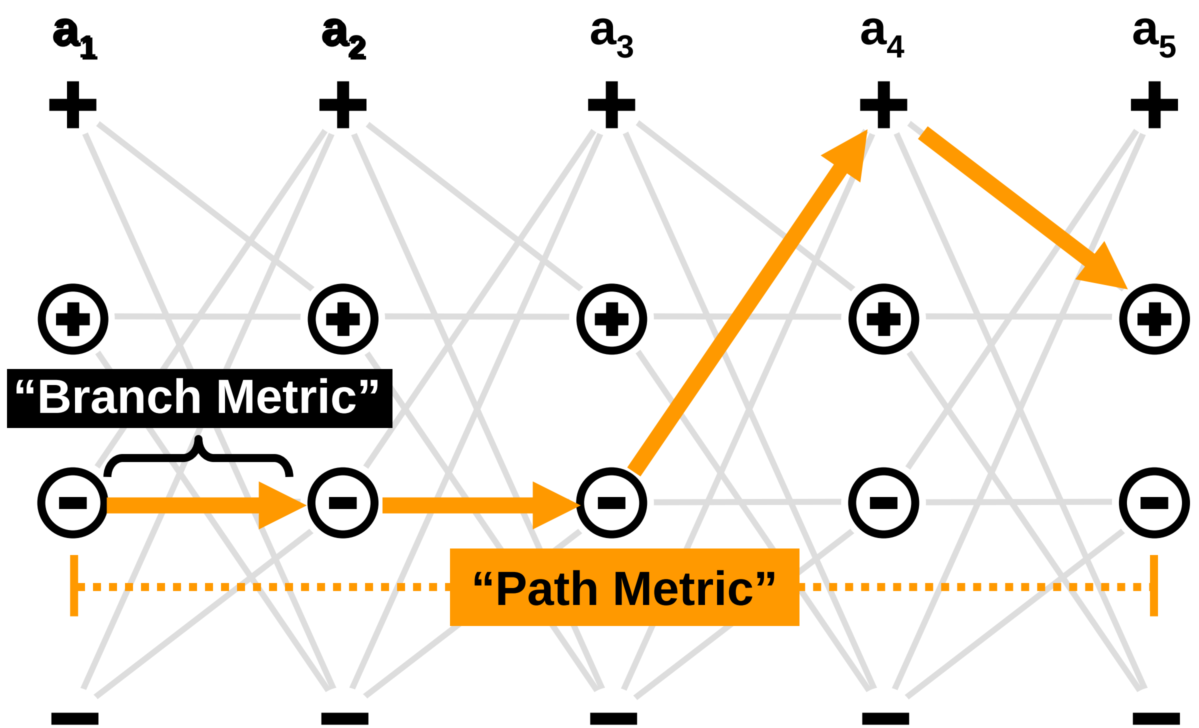
There are numerous possible paths through the trellis

The Trellis



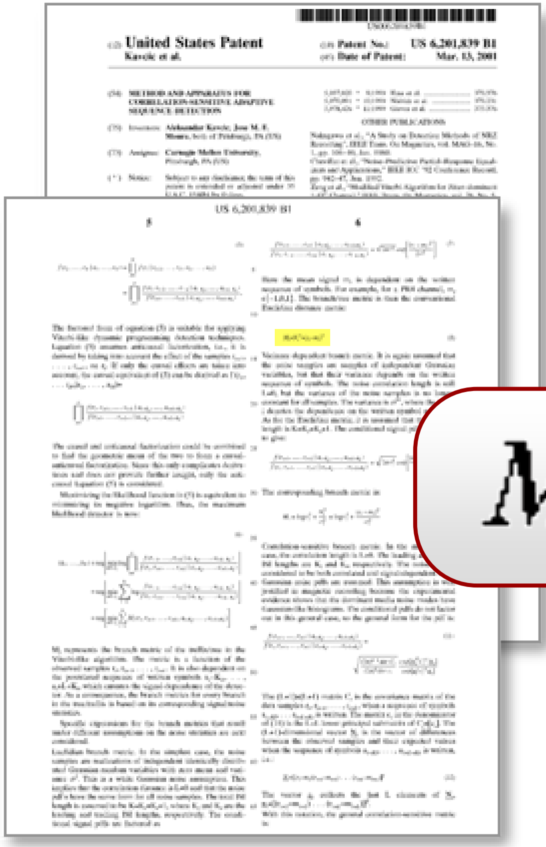
Finding the most likely path through the trellis
will reveal the symbols written on the disk

“Branch Metric” and “Path Metric” in the Trellis



Branch Metric	Value of Branch between two nodes
Path Metric	Sum of separate Branch Metrics

The Kavcic-Moura Patents Describe the Prior Art


United States Patent
Kavcic et al.
Patent No.: US 6,201,839 B1
Date of Patent: Mar. 13, 2001
US 6,201,839 B1

$$M_i = N_i^2 = (r_i - m_i)^2$$

Source: ’839 Patent
Equation 8 (6:13)

Prior Art Branch Metric Calculation

Readings (r_t) are algorithmically compared to Target Values (m_i) to determine most likely sequence of bits or symbols on the disk

$$BM_i = (r_t - m_i)^2$$

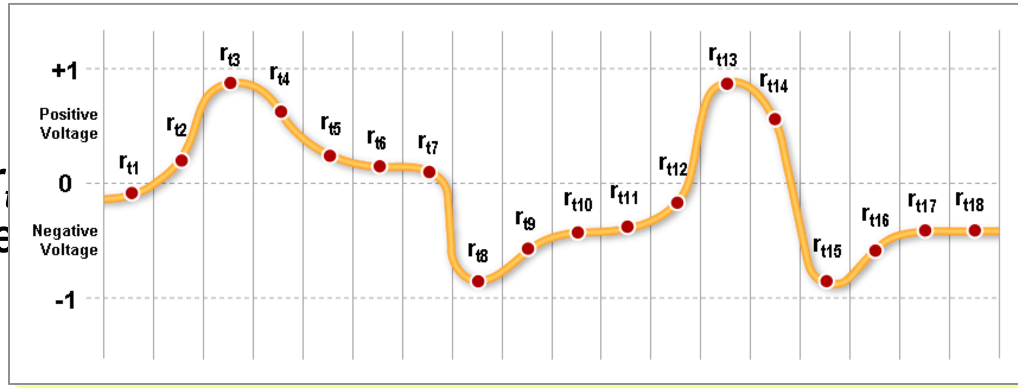
Branch Metric

Reading

Target Value

Prior Art Branch Metric Calculation

Readings (r_t … ues (m_i) to
determine … the disk



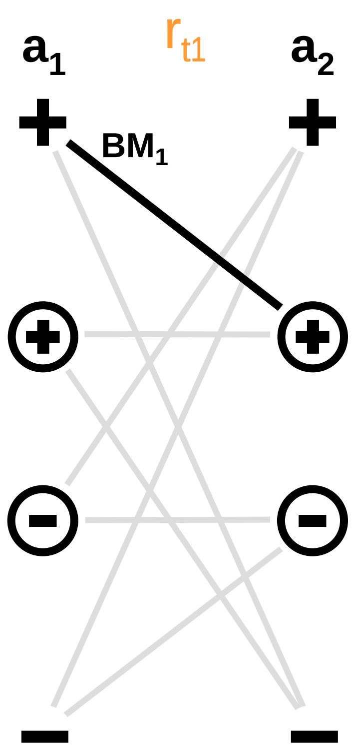
$$BM_i = (r_t - m_i)^2$$

Branch Metric #

Specific Time Index of Sample

Branch Metric #

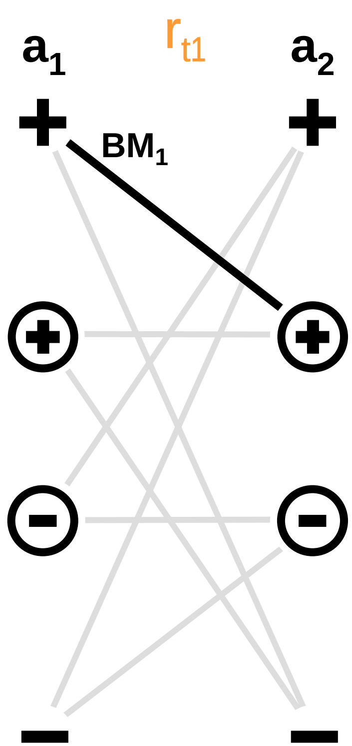
Branch Metrics



Computing Branch Metric 1 (BM_1)

$$BM_i = (r_t - m_i)^2$$

Branch Metrics

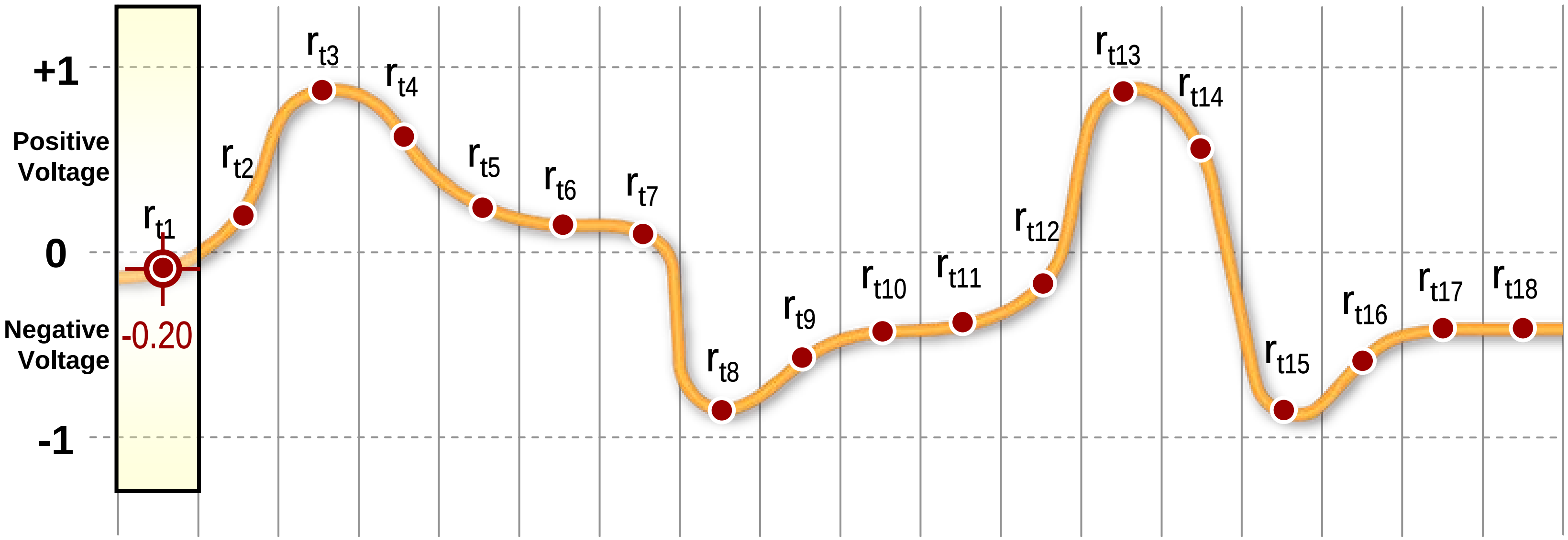


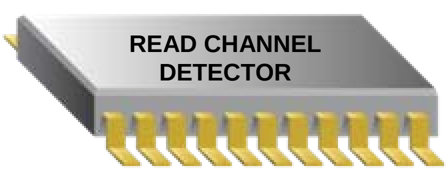
Computing Branch Metric 1 (BM_1)

?

$$BM_1 = (r_{t1} - m_1)^2$$

r-Values are Obtained From Readings Taken at Specific Time Intervals



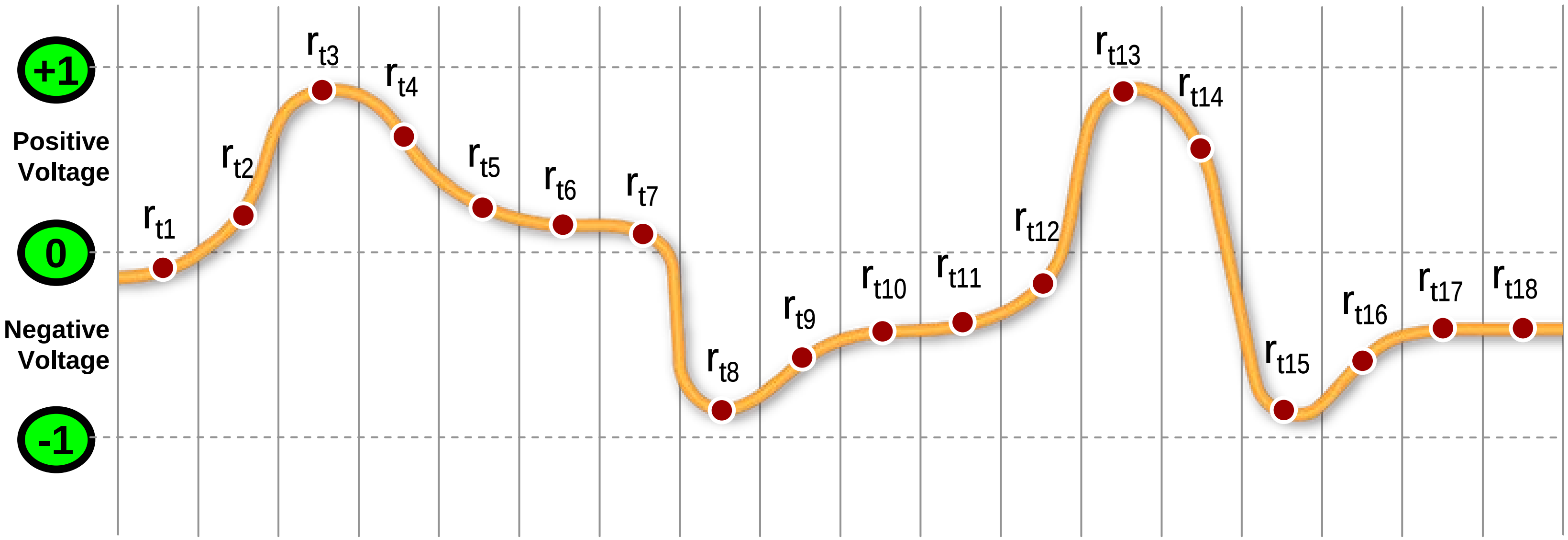


?

$$BM_1 = (\quad - m_1)^2$$

Target Values

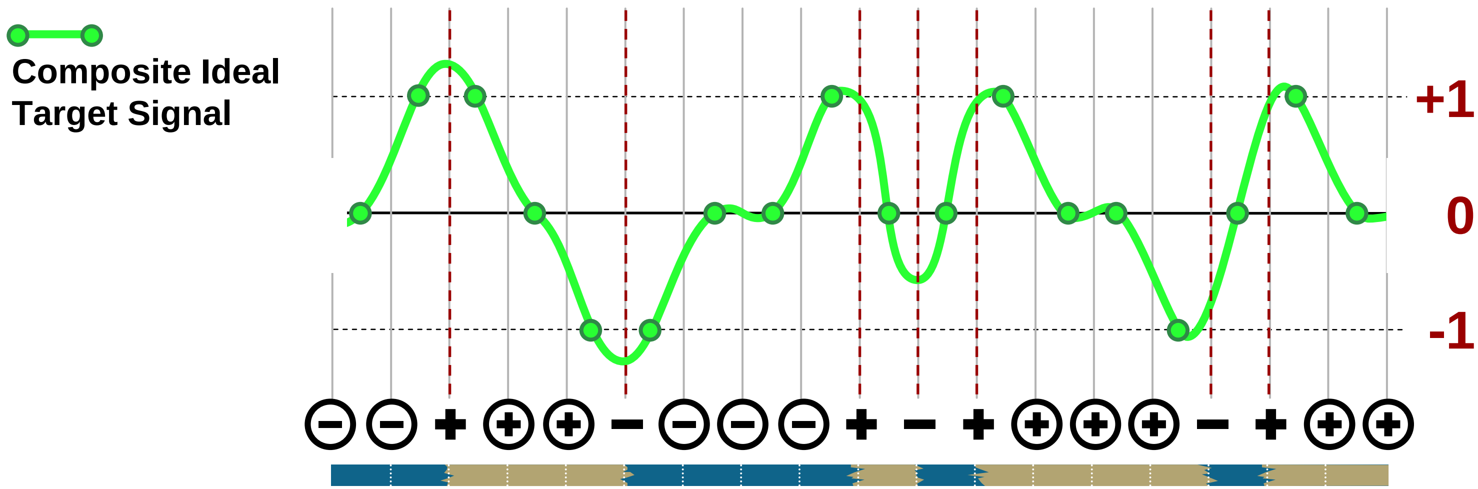
Target Values (m_i)

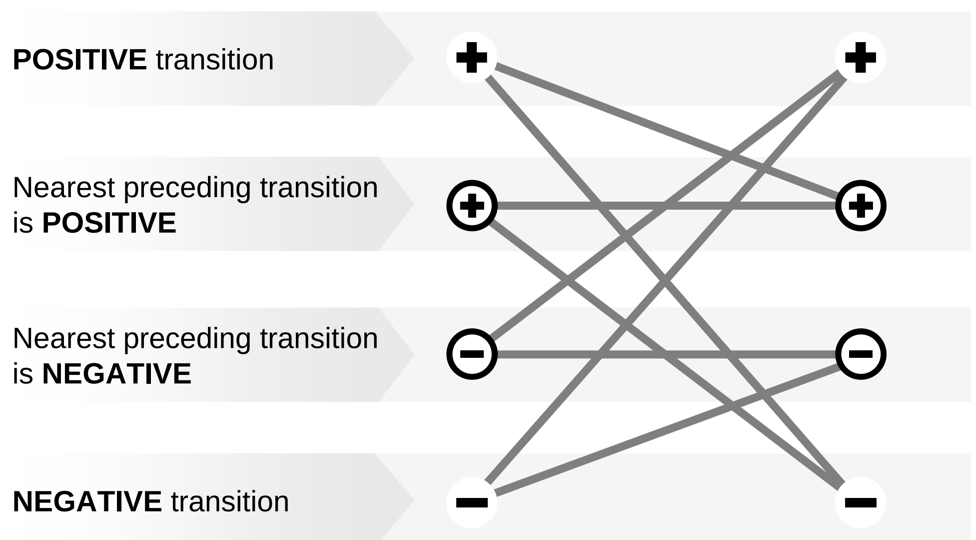


?

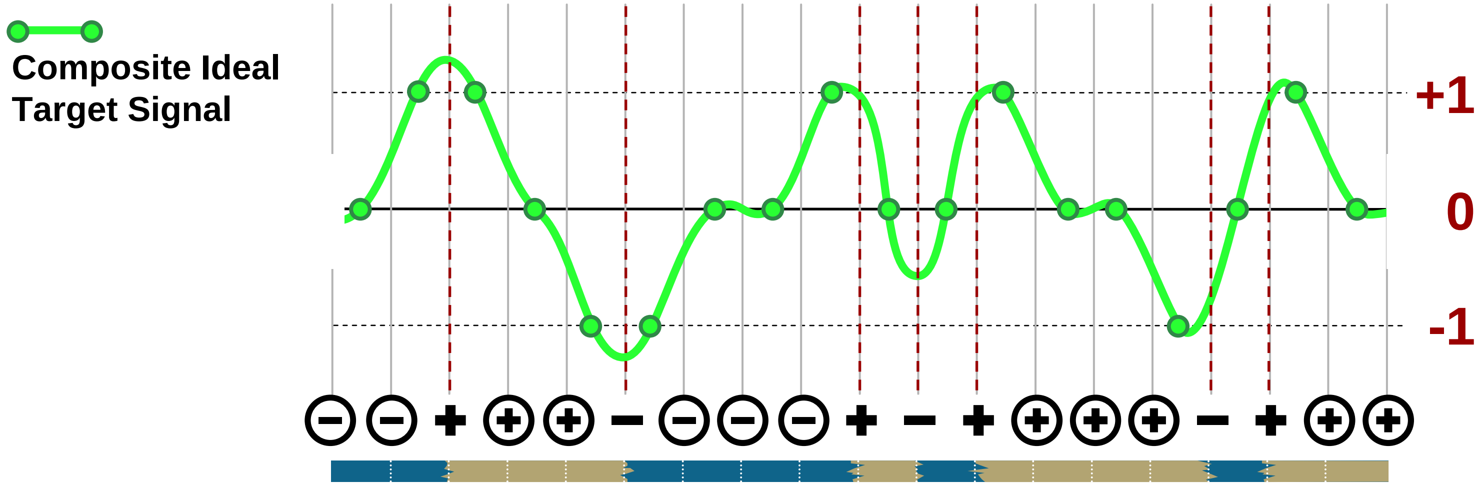
$$BM_1 = (-0.20 - m_1)^2$$

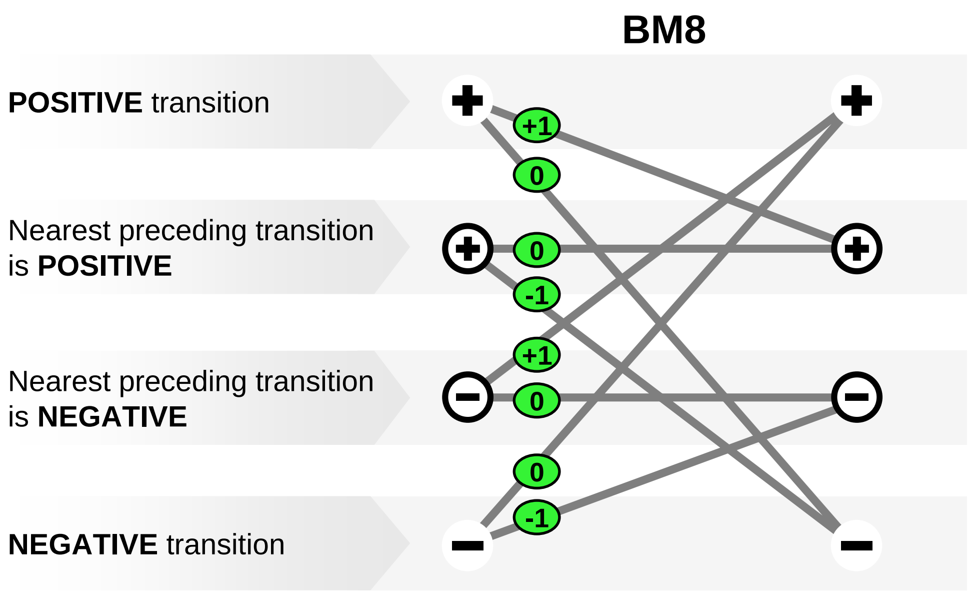
Ideal Target Values



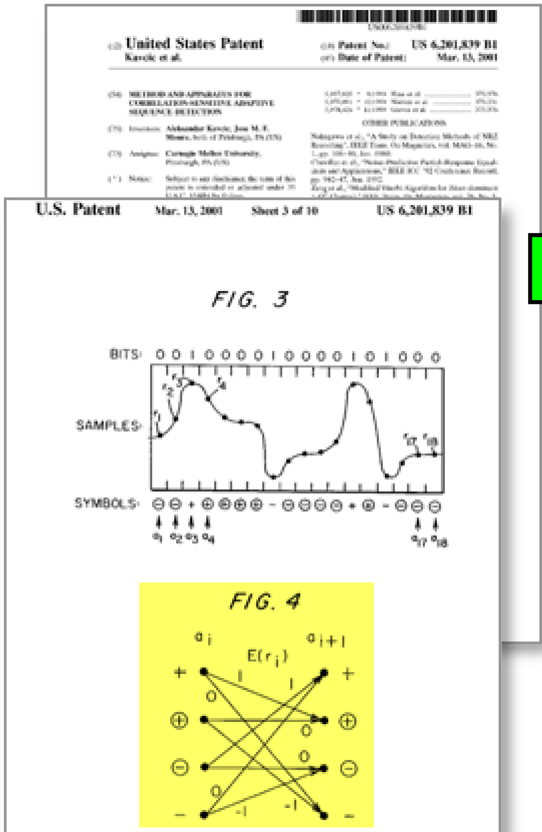


Ideal Target Values

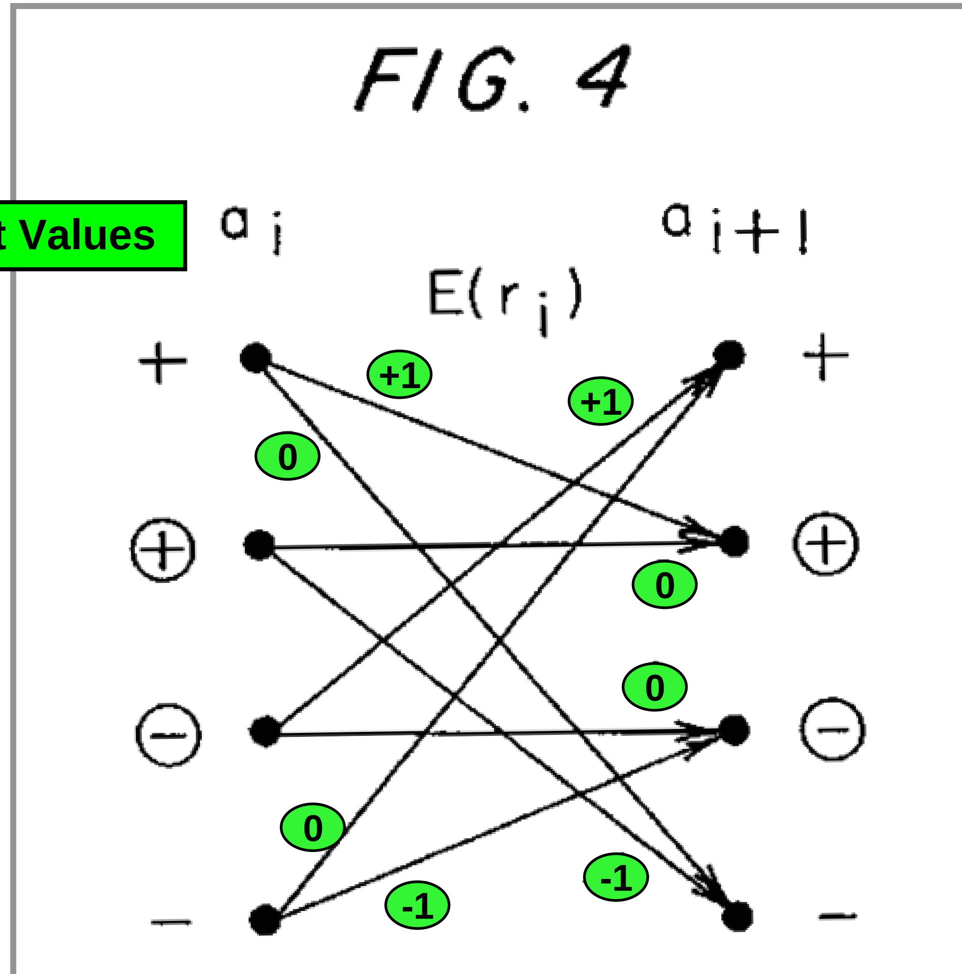




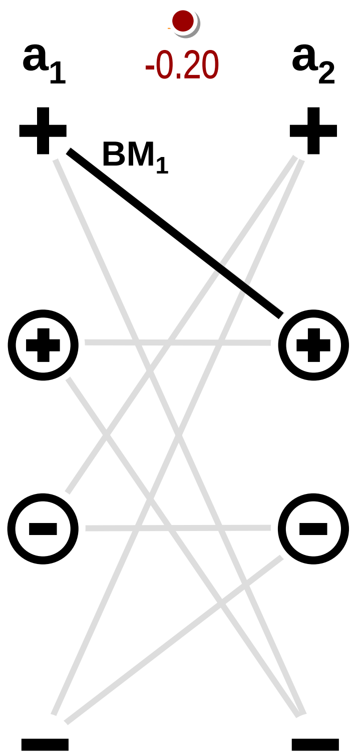
Ideal Target Values in Figure 4



Target Values



Computing Branch Metrics



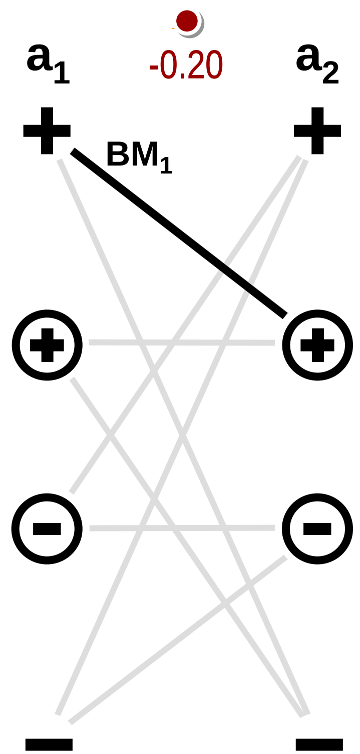
Computing Branch Metric 1 (BM_1)

$m_1 = +1$

?

$$BM_1 = (-0.20 - m_1)^2$$

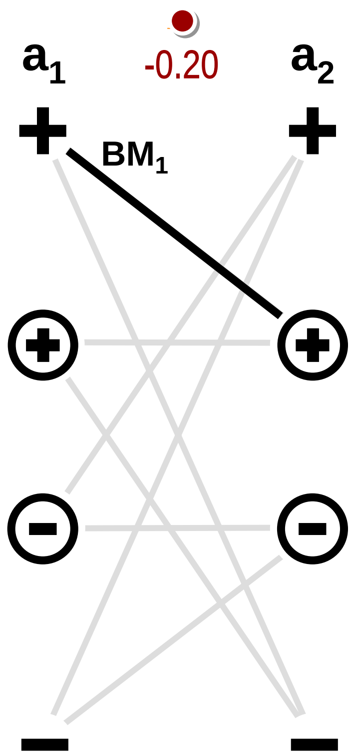
Computing Branch Metrics



Computing Branch Metric 1 (BM_1)

$$BM_1 = (-0.20 - 1)^2$$

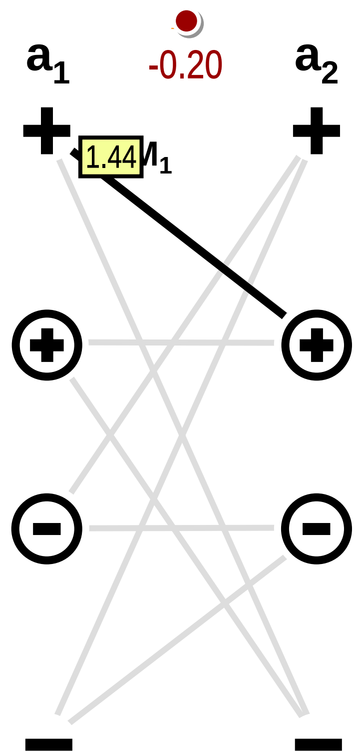
Computing Branch Metrics



Computing Branch Metric 1 (BM_1)

$$BM_1 = (-1.20 \quad)^2$$

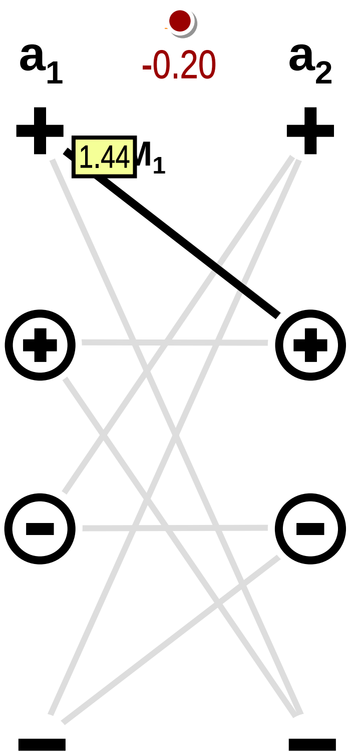
Computing Branch Metrics



Computing Branch Metric 1 (BM_1)

$$BM_1 = 1.44$$

Computing Branch Metrics



$BM_1 = 1.44$

$BM_2 = (r_1 - m_2)^2$

$BM_3 = (r_1 - m_3)^2$

$BM_4 = (r_1 - m_4)^2$

$BM_5 = (r_1 - m_5)^2$

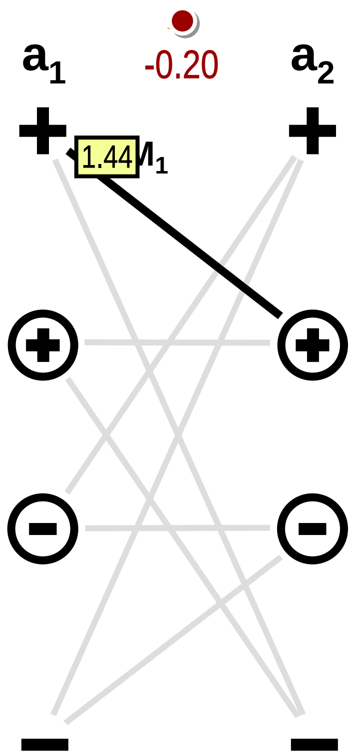
$BM_6 = (r_1 - m_6)^2$

$BM_7 = (r_1 - m_7)^2$

$BM_8 = (r_1 - m_8)^2$

$$BM_i = (r_t - m_i)^2$$

Computing Branch Metrics



$$BM_1 = 1.44$$

$$BM_2 = (\, r_1 - m_2)^2$$

$$BM_3 = (\, r_1 - m_3)^2$$

$$BM_4 = (\, r_1 - m_4)^2$$

$$BM_5 = (\, r_1 - m_5)^2$$

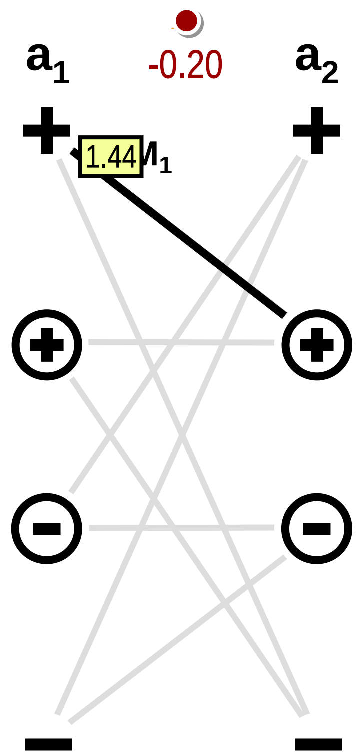
$$BM_6 = (\, r_1 - m_6)^2$$

$$BM_7 = (\, r_1 - m_7)^2$$

$$BM_8 = (\, r_1 - m_8)^2$$

$$BM_i = (\, r_t - m_i\,)^2$$

Computing Branch Metrics



$BM_1 = 1.44$

$BM_2 = (-0.20 - m_2)^2$

$BM_3 = (-0.20 - m_3)^2$

$BM_4 = (-0.20 - m_4)^2$

$BM_5 = (-0.20 - m_5)^2$

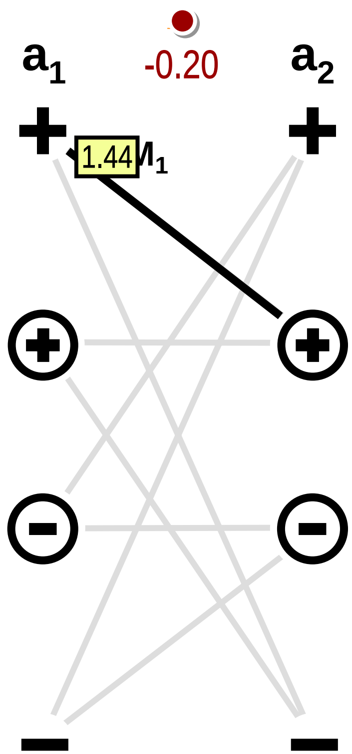
$BM_6 = (-0.20 - m_6)^2$

$BM_7 = (-0.20 - m_7)^2$

$BM_8 = (-0.20 - m_8)^2$

$$BM_i = (\, r_t - m_i \,)^2$$

Computing Branch Metrics



$BM_1 = 1.44$

$BM_2 = (-0.20 - m_2)^2$ $m_2 = 0$

$BM_3 = (-0.20 - m_3)^2$ $m_3 = 0$

$BM_4 = (-0.20 - m_4)^2$ $m_4 = -1$

$BM_5 = (-0.20 - m_5)^2$ $m_5 = 1$

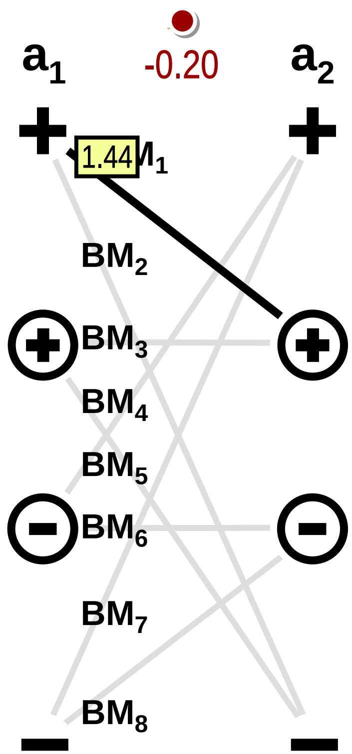
$BM_6 = (-0.20 - m_6)^2$ $m_6 = 0$

$BM_7 = (-0.20 - m_7)^2$ $m_7 = 0$

$BM_8 = (-0.20 - m_8)^2$ $m_8 = -1$

$$BM_i = (r_t - m_i)^2$$

Computing Branch Metrics



$$BM_1 = 1.44$$

$$BM_2 = (-0.20 - 0)^2$$

$$BM_3 = (-0.20 - 0)^2$$

$$BM_4 = (-0.20 - -1)^2$$

$$BM_5 = (-0.20 - 1)^2$$

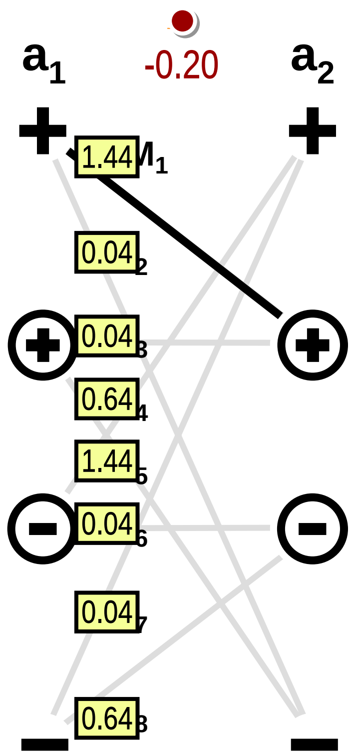
$$BM_6 = (-0.20 - 0)^2$$

$$BM_7 = (-0.20 - 0)^2$$

$$BM_8 = (-0.20 - -1)^2$$

$$\boxed{BM_i = (r_t - m_i)^2}$$

Computing Branch Metrics



$BM_1 = 1.44$

$BM_2 = 0.04$

$BM_3 = 0.04$

$BM_4 = 0.64$

$BM_5 = 1.44$

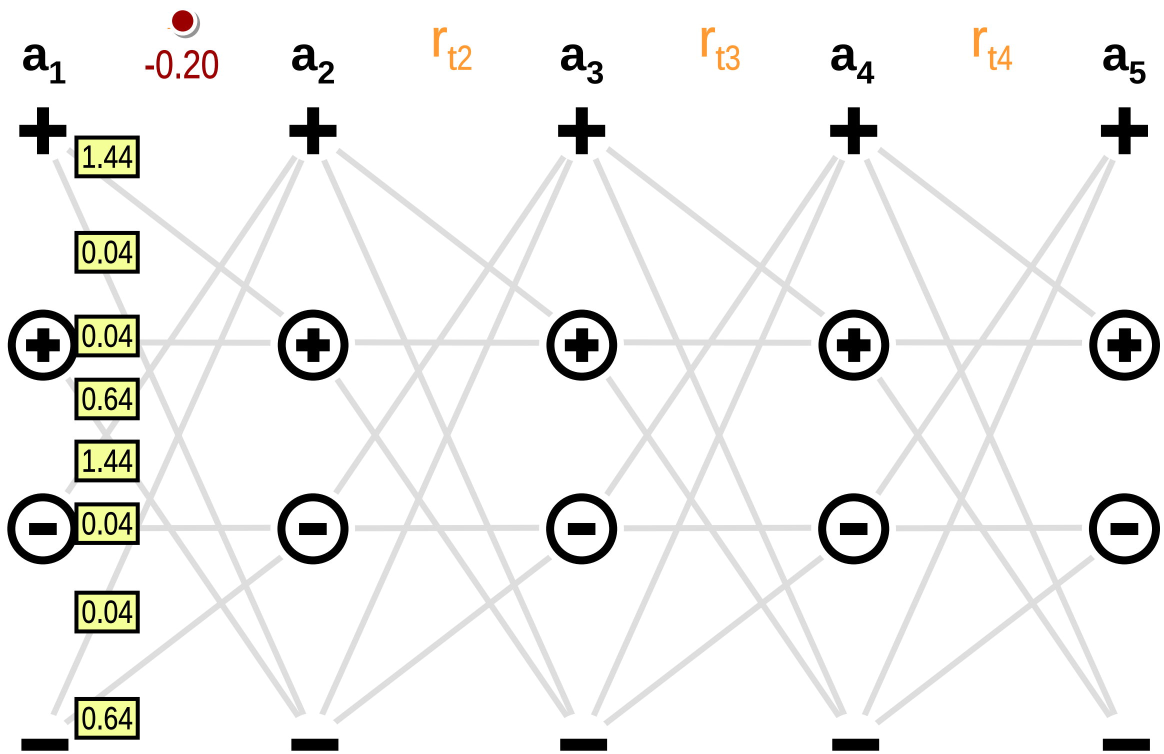
$BM_6 = 0.04$

$BM_7 = 0.04$

$BM_8 = 0.64$

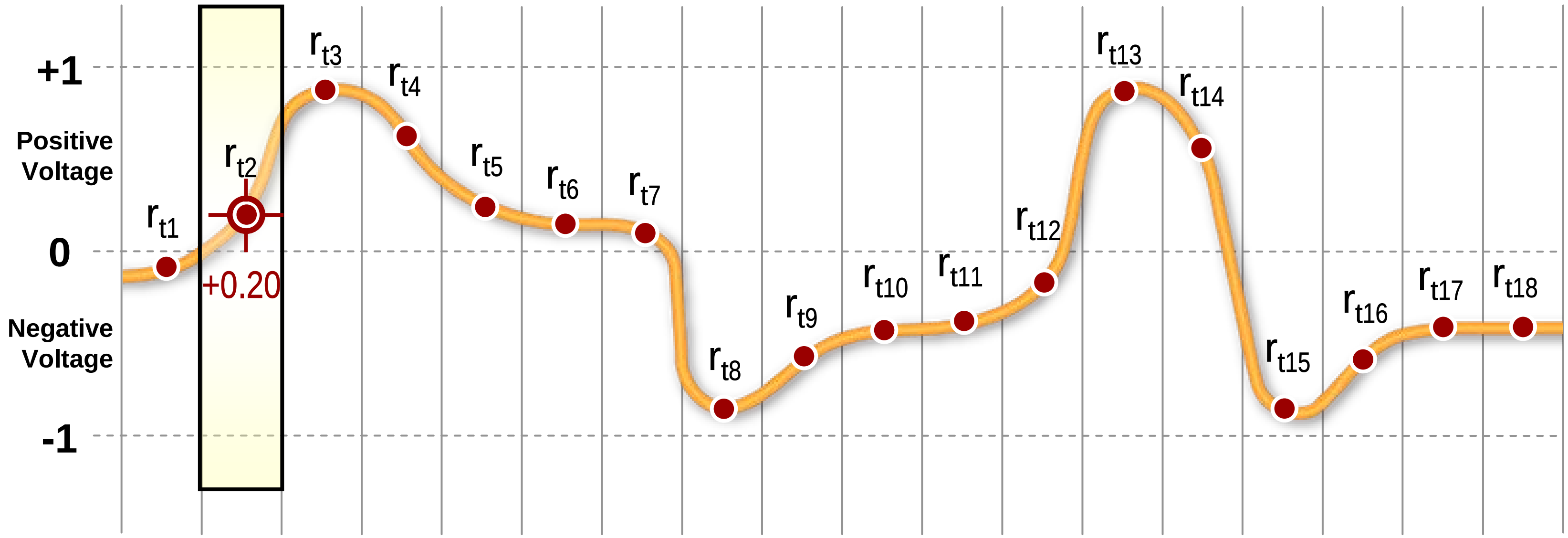
$$BM_i = (\ r_t - m_i\ )^2$$

Computing Branch Metrics



$$BM_i = (r_t - m_i)^2$$

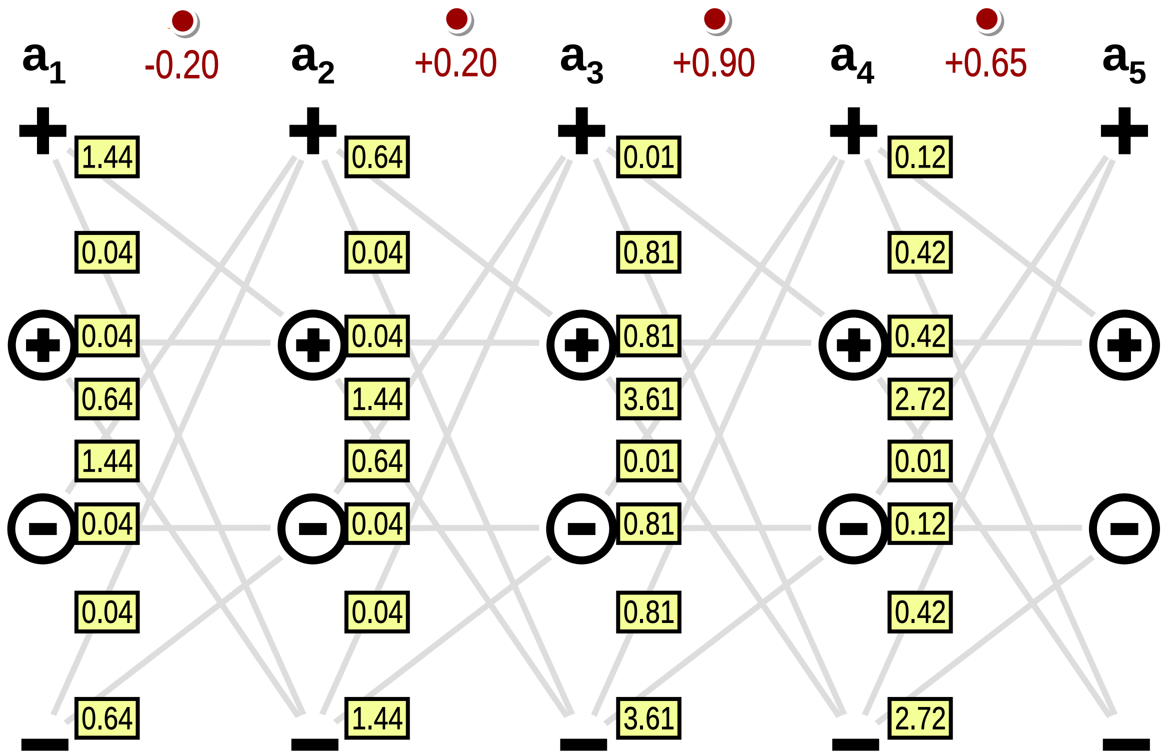
r-Values are Obtained From Readings Taken at Specific Time Intervals



?

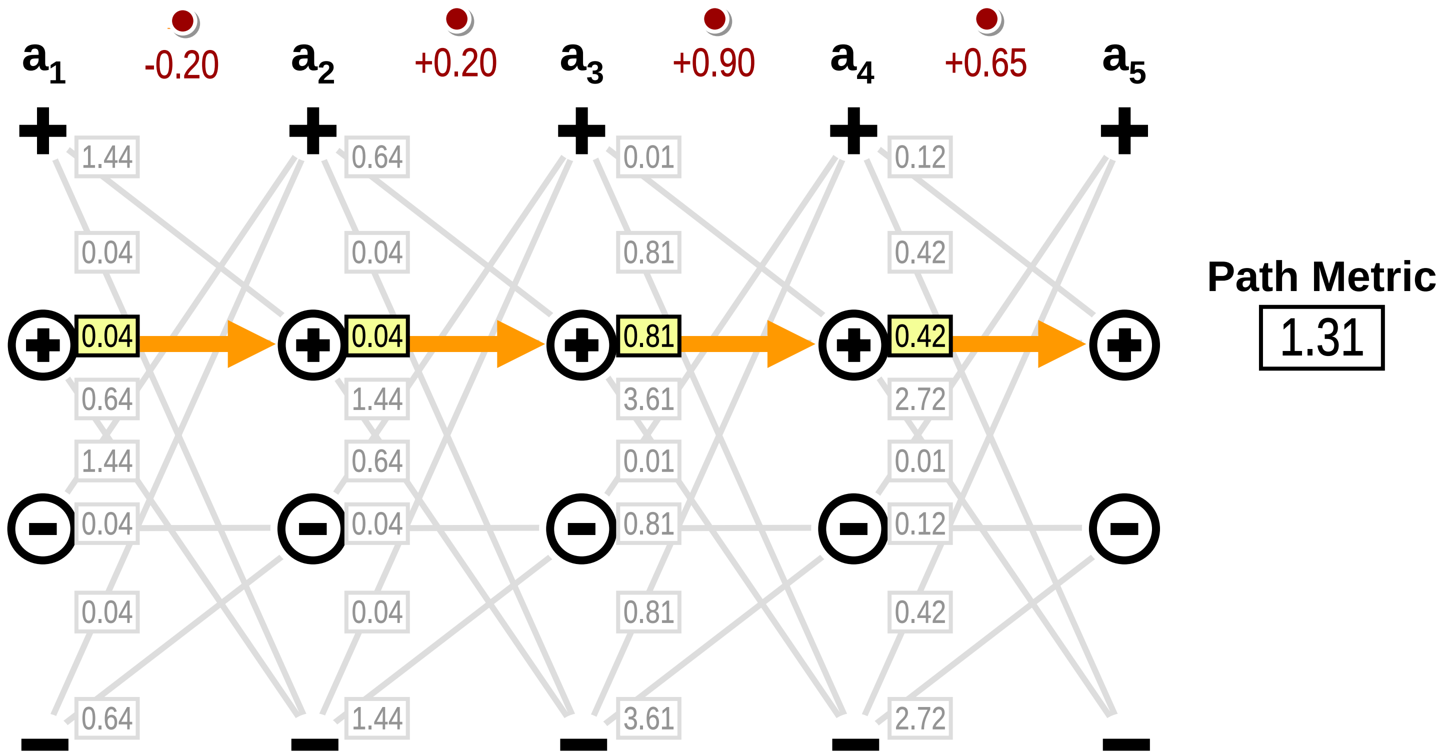
$$BM_1 = (\quad - m_1)^2$$

Computing Branch Metrics



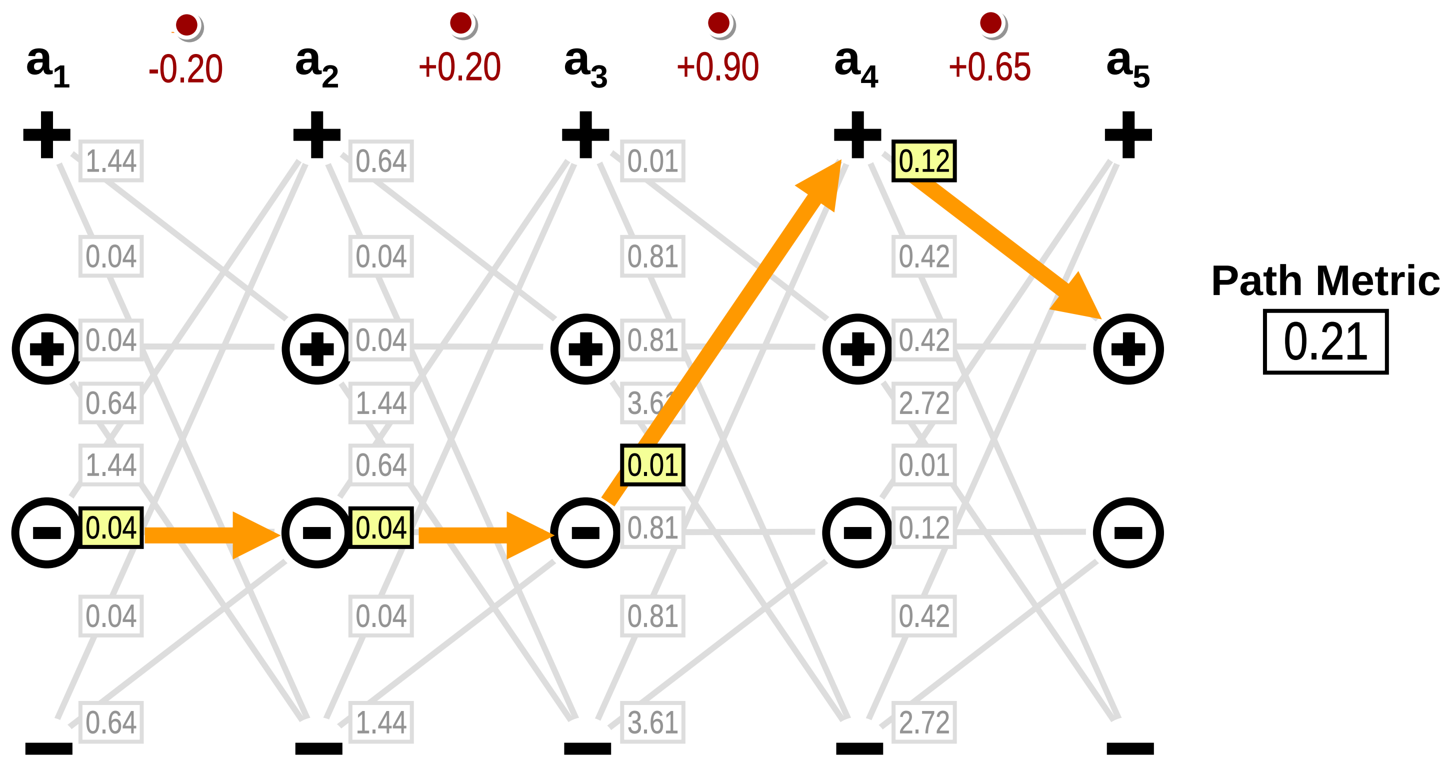
$$BM_i = (r_t - m_i)^2$$

Path Metrics



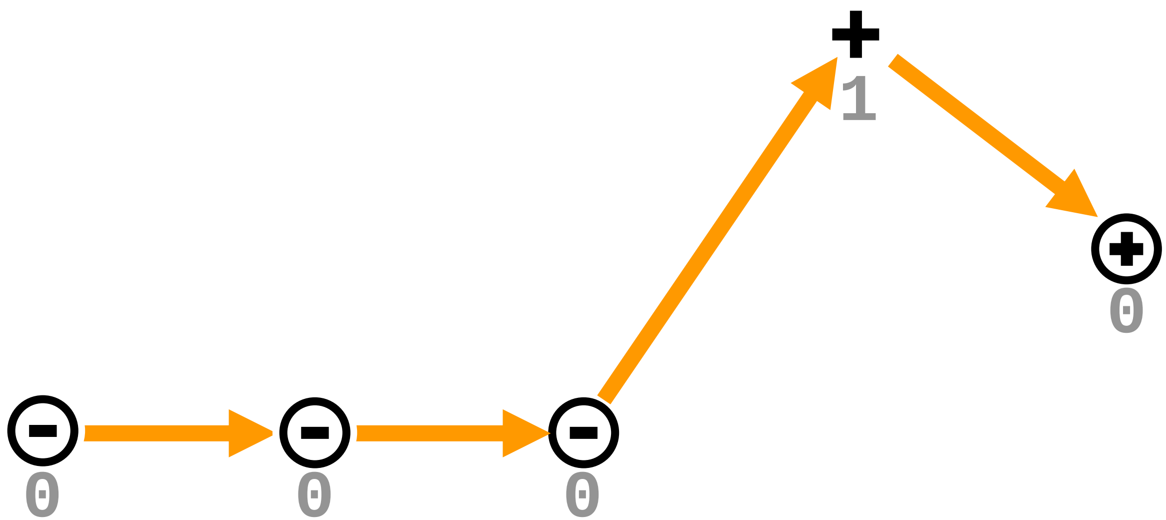
The path with the lowest cumulative total is the most likely sequence

Path Metrics



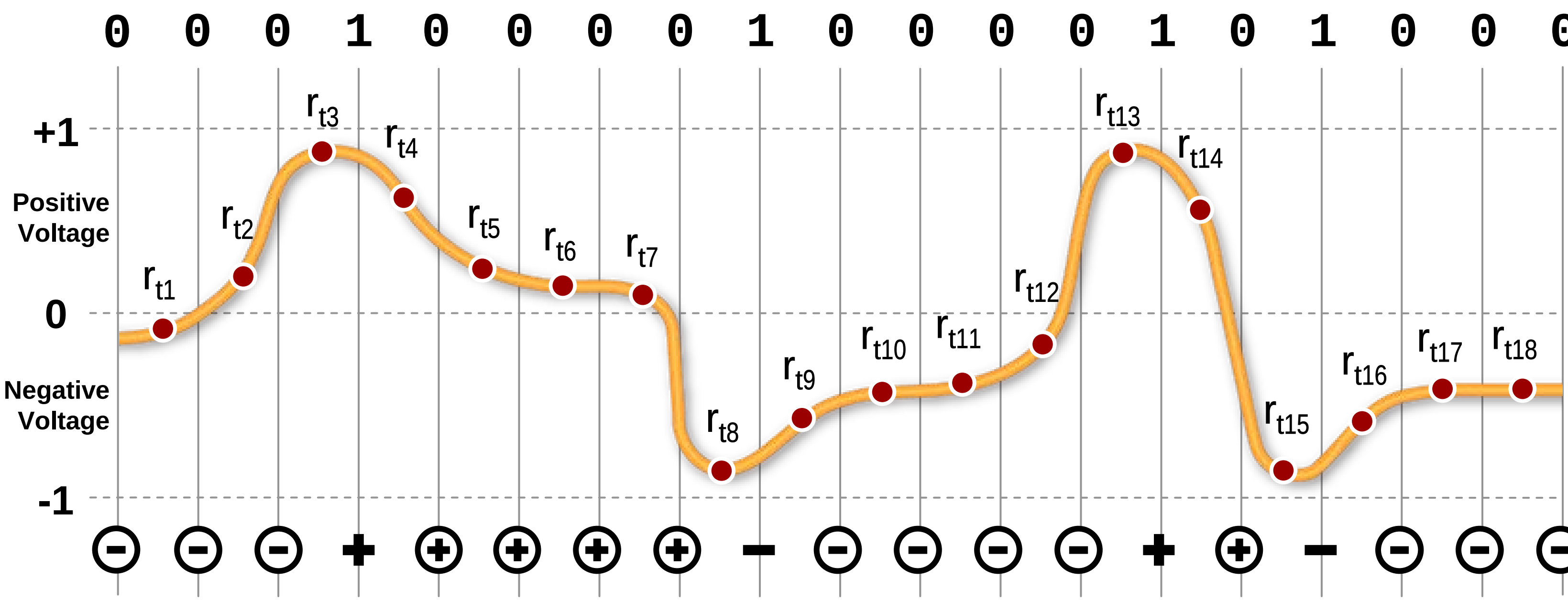
The path with the lowest cumulative total is the most likely sequence

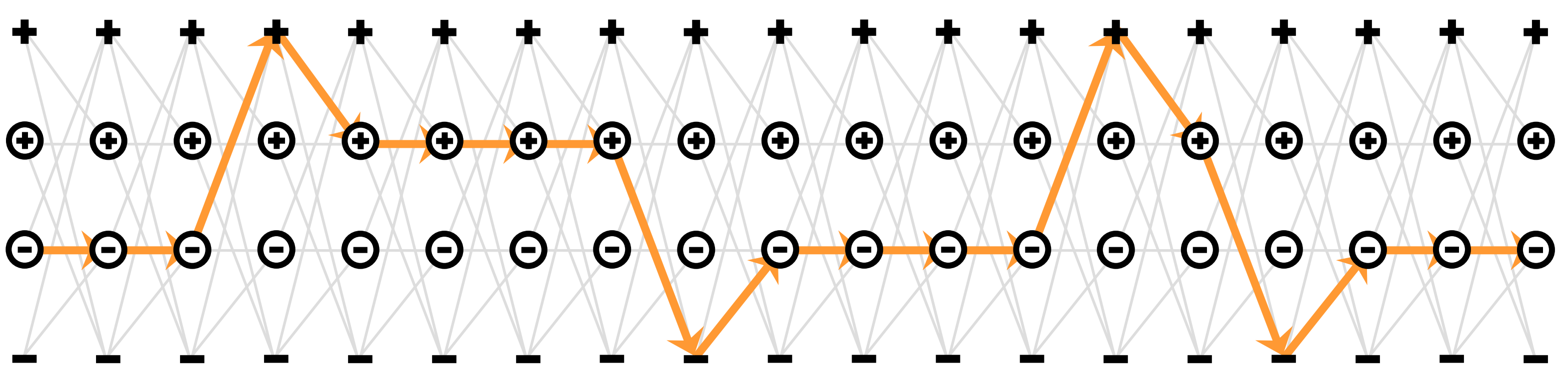
Path Metrics



The path with the lowest cumulative total is the most likely sequence

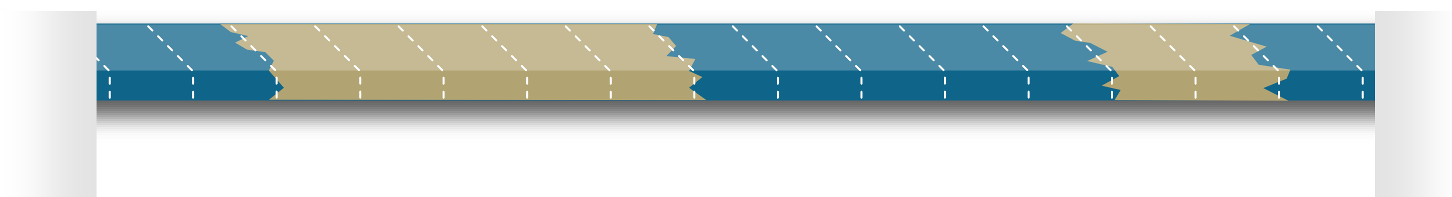
Determining the Bit Sequence





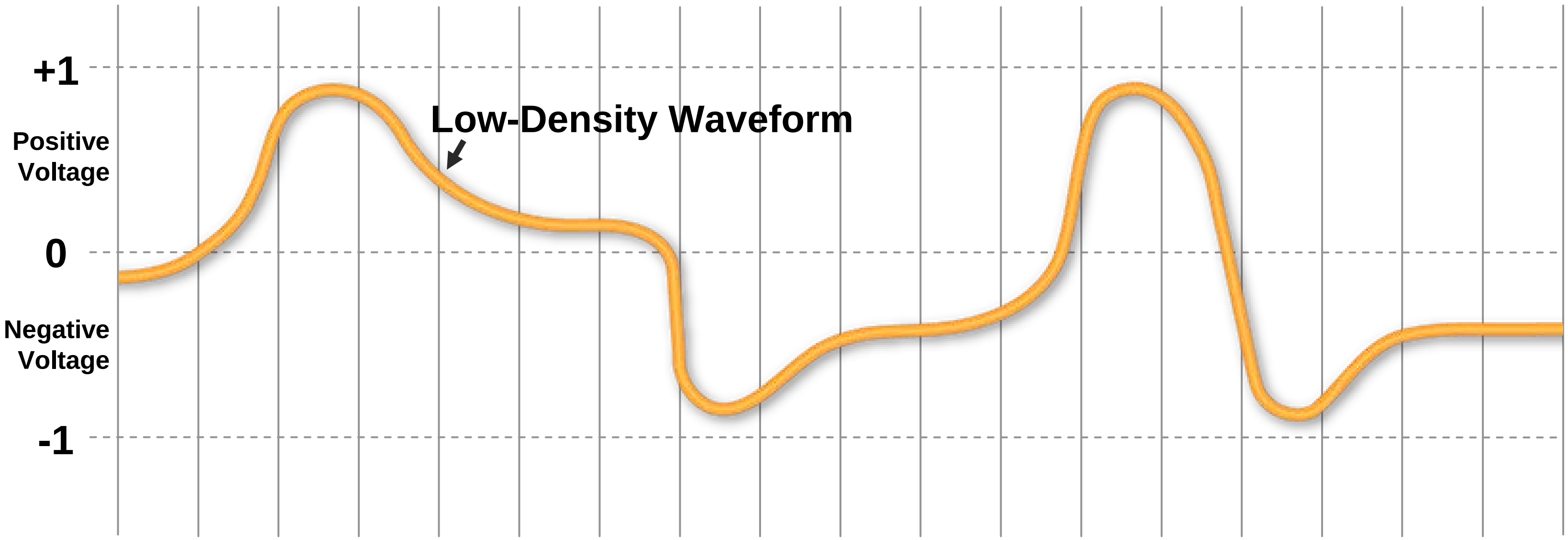
Determining the Bit Sequence

0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0

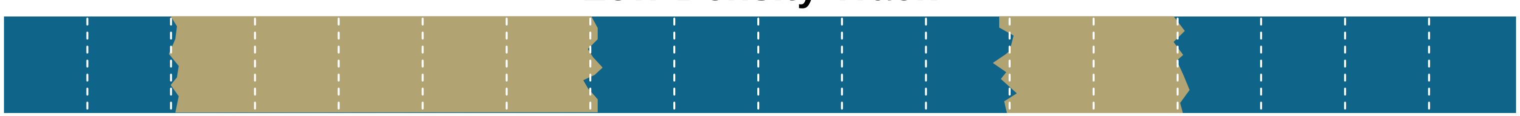


Viterbi Detectors in a High Data Density Environment

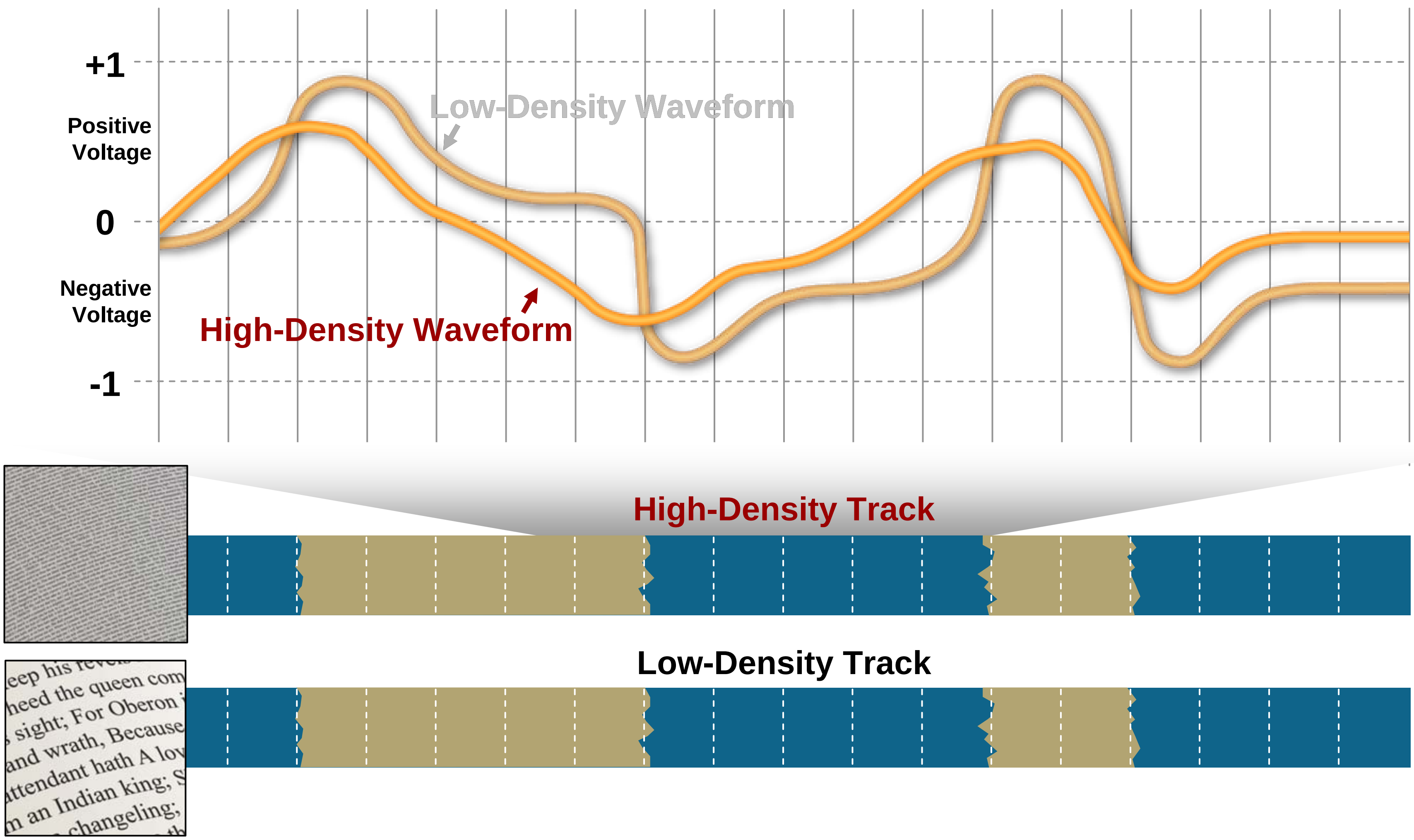
Viterbi Detectors in a High Data Density Environment



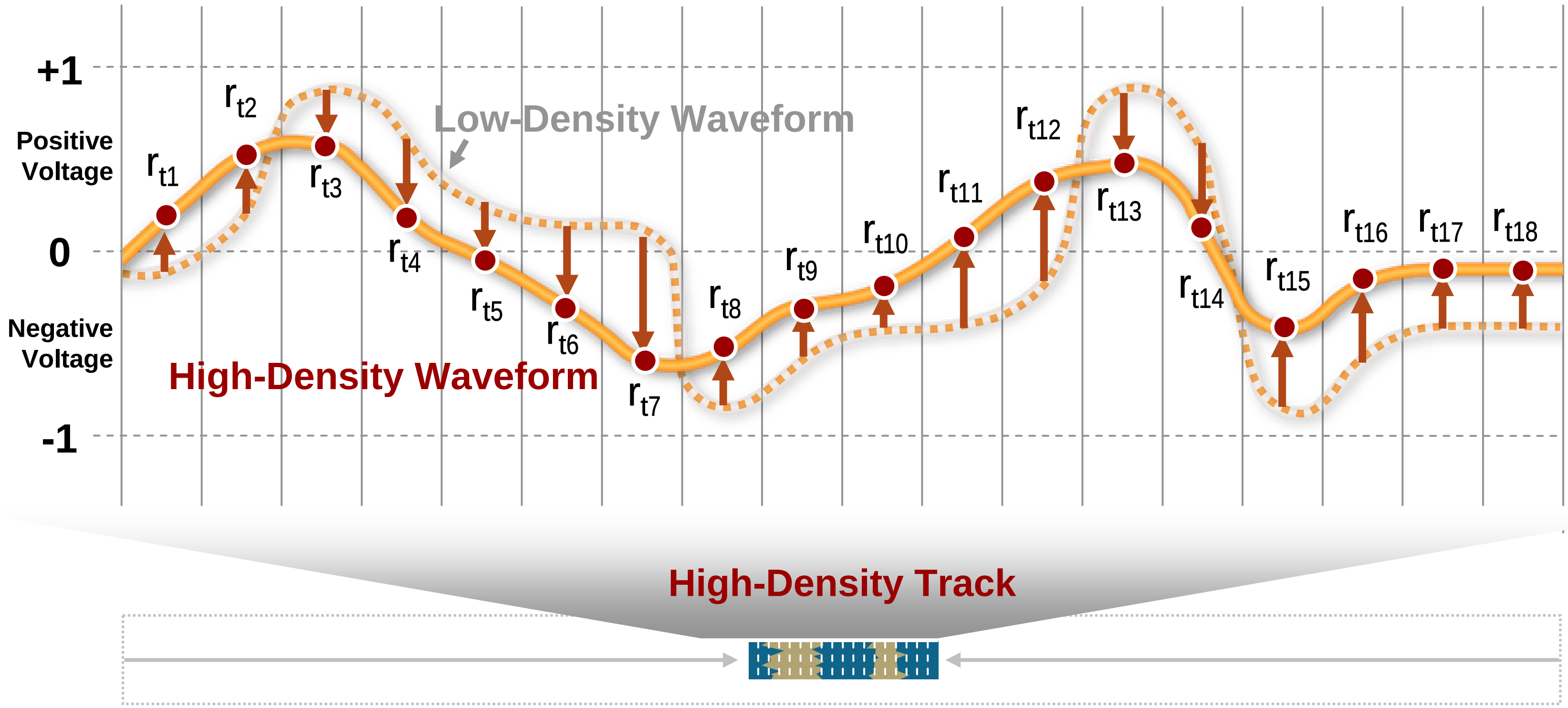
Low-Density Track



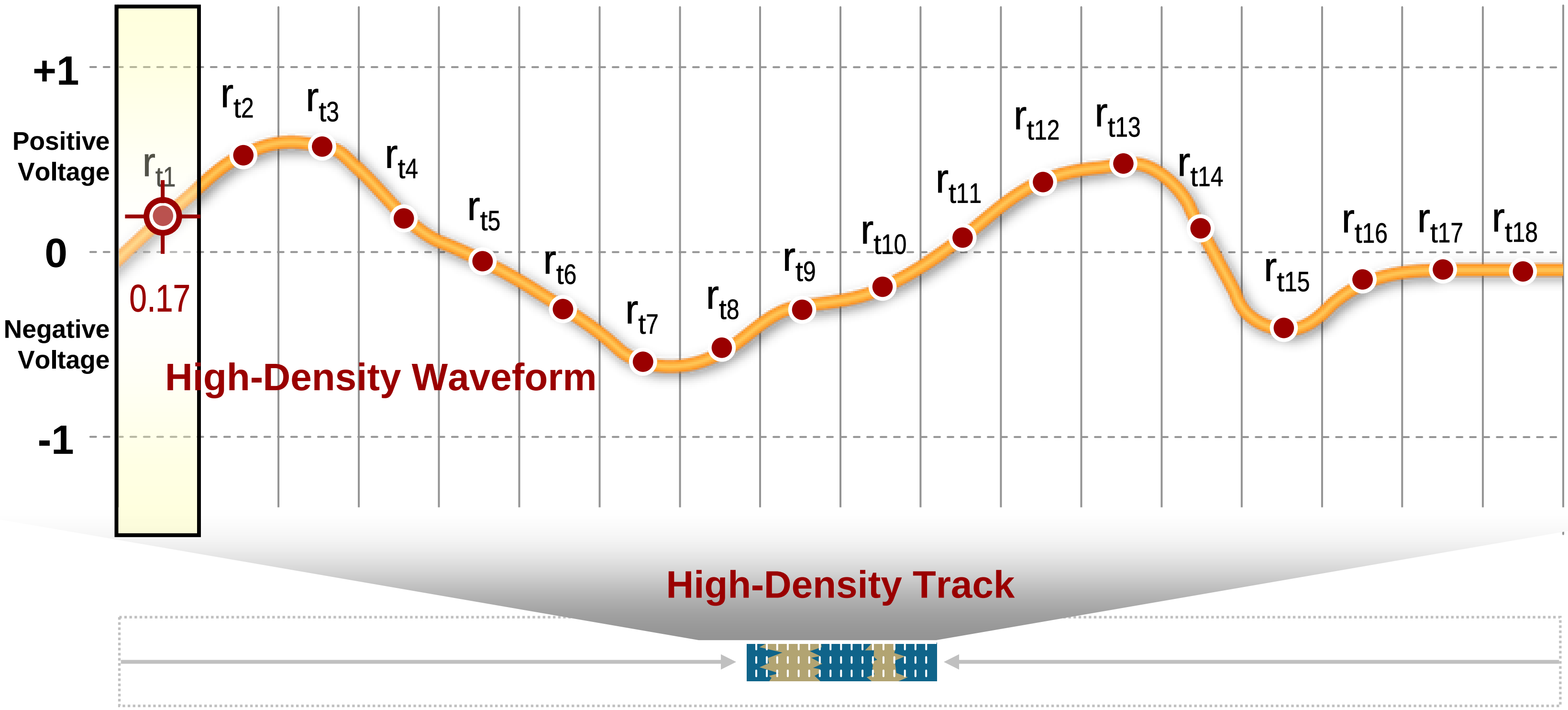
Viterbi Detectors in a High Data Density Environment



Viterbi Detectors in a High Data Density Environment



Viterbi Detectors in a High Data Density Environment



?

$$BM_1 = (\quad - m_1)^2$$

Viterbi Detectors in a High Data Density Environment

Low-Density Reading

r_{t1}

-0.20

$BM_1 = \boxed{1.44}$

High-Density Reading

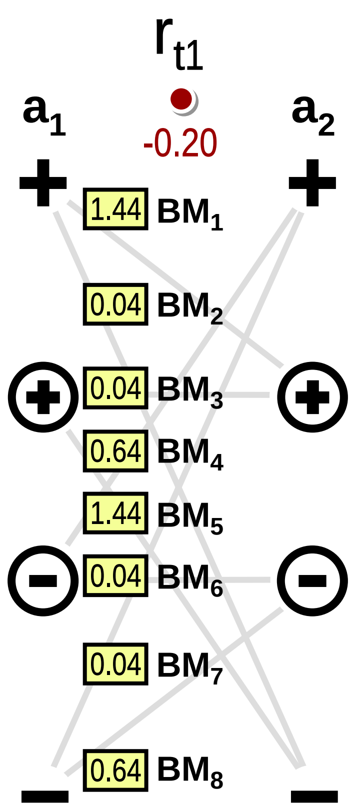
r_{t1}

+0.17

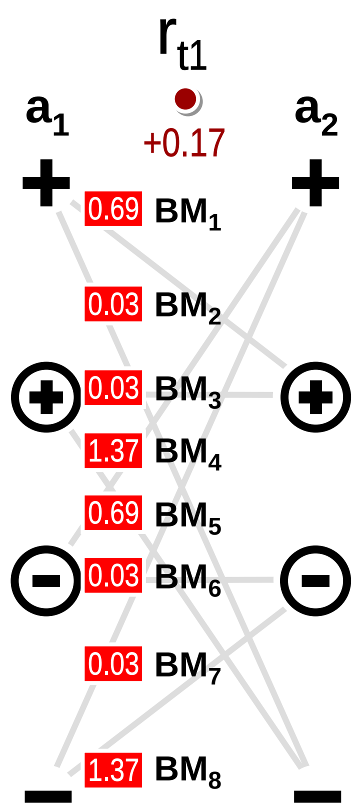
$BM_1 = 0.69$

Viterbi Detectors in a High Data Density Environment

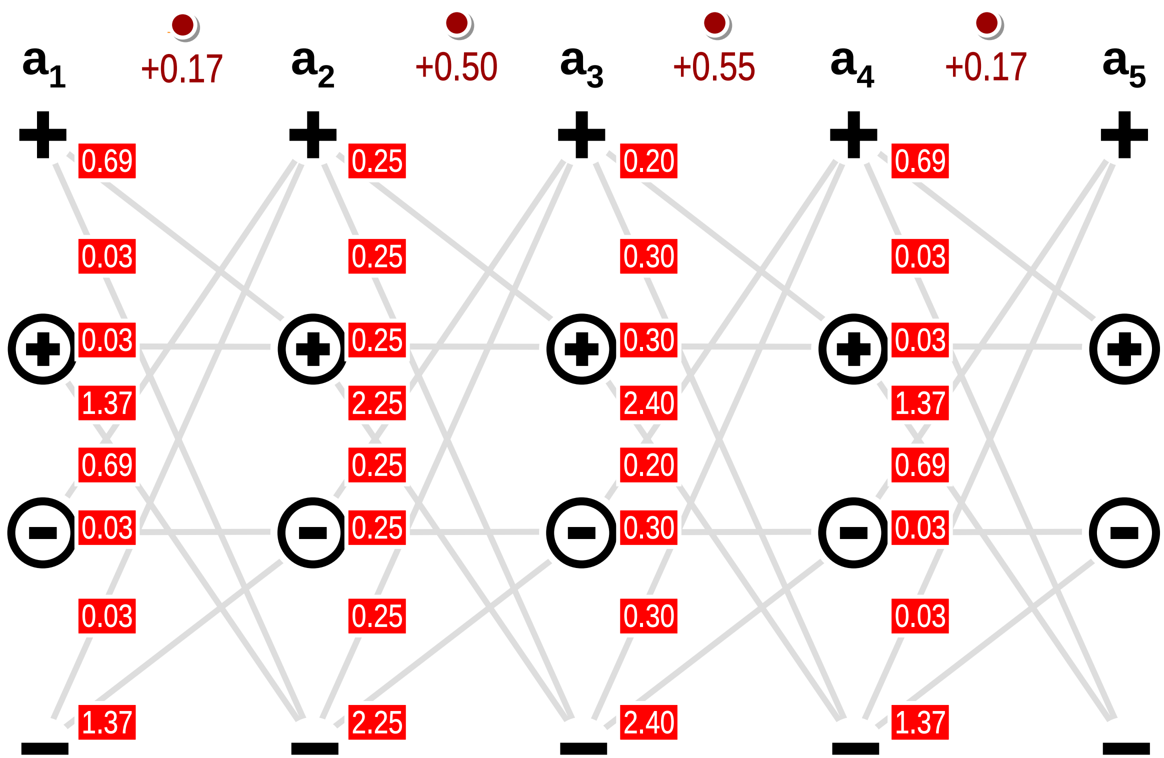
Low-Density Reading



High-Density Reading

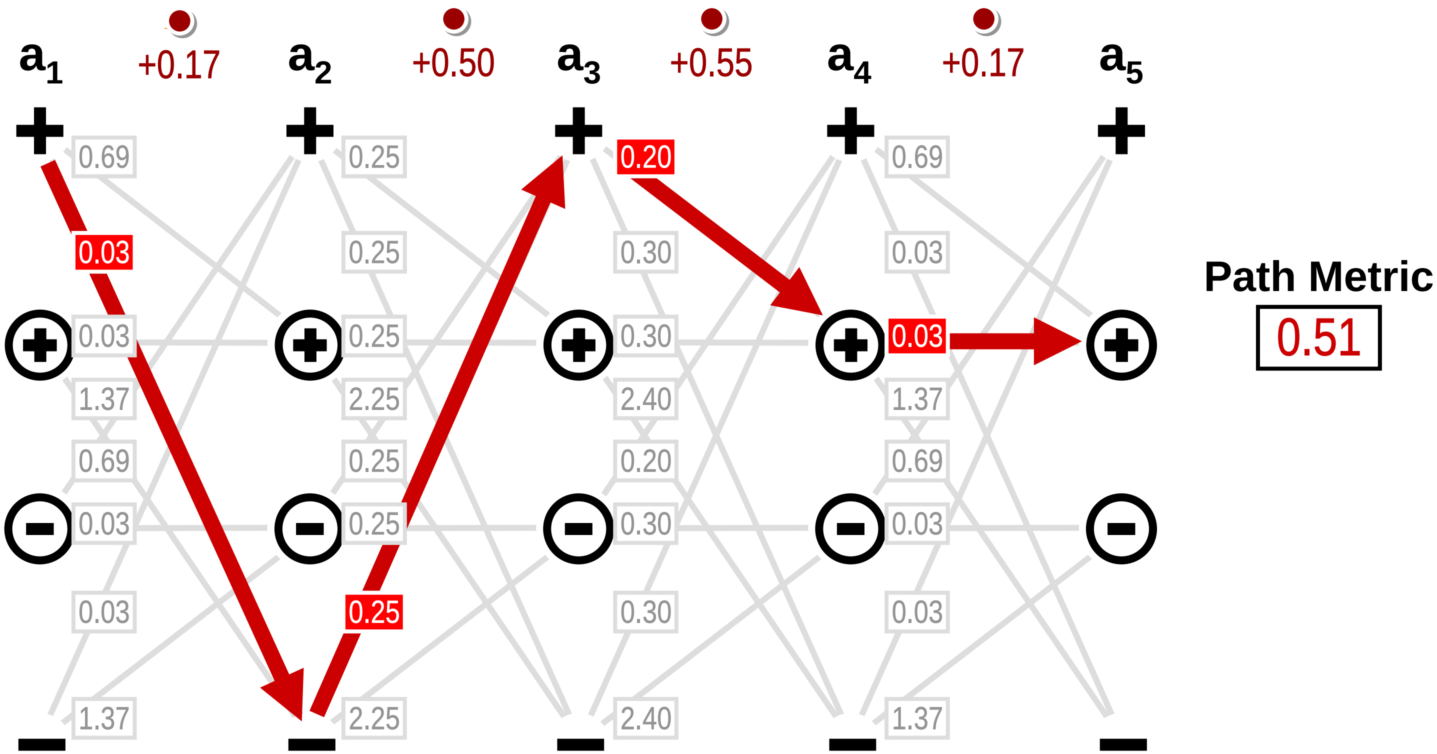


High Data Density Branch Metrics



$$BM_i = (\, r_t - m_i \,)^2$$

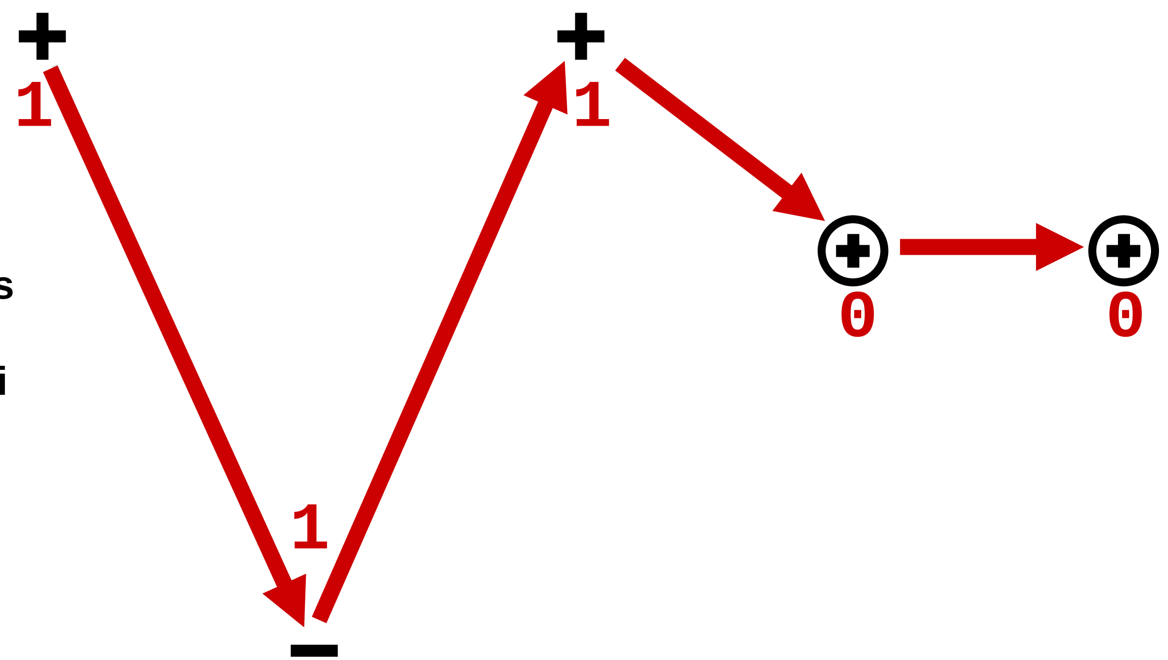
High Data Density Path Metric



$$BM_i = (r_t - m_i)^2$$

High Data Density Path Metric

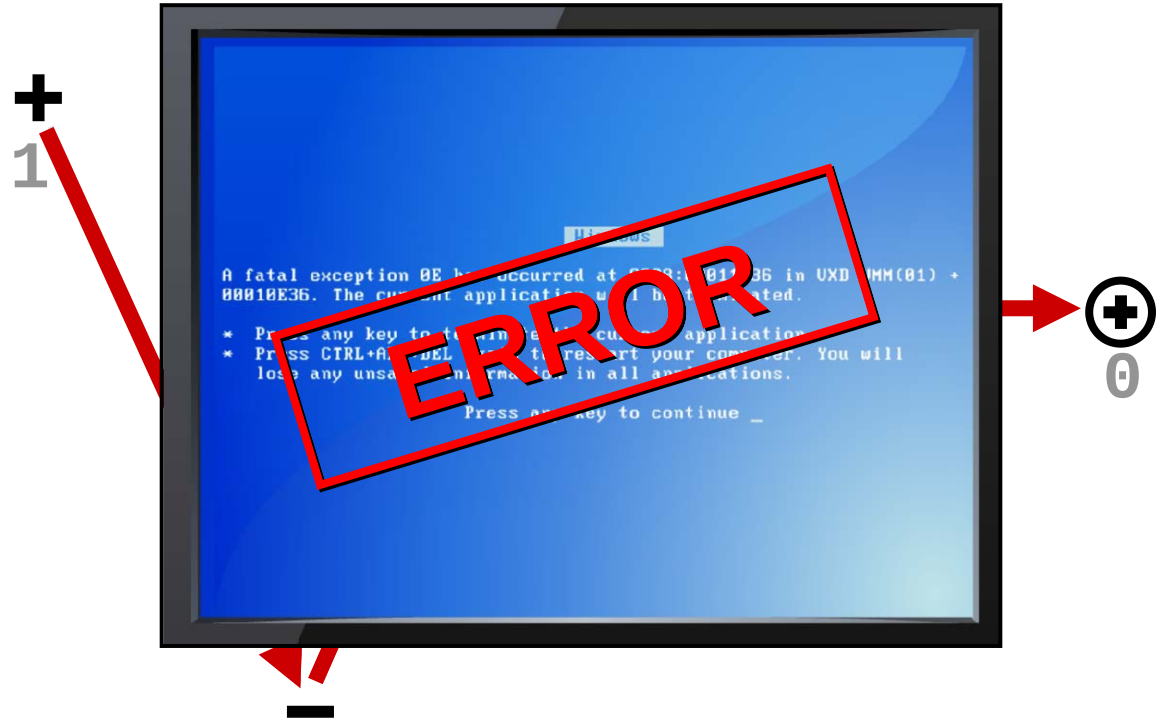
Bit sequence as determined by Prior Art Viterbi detector:



Actual bit sequence:

0 0 0 1 0

High Data Density Path Metric



Path Metric

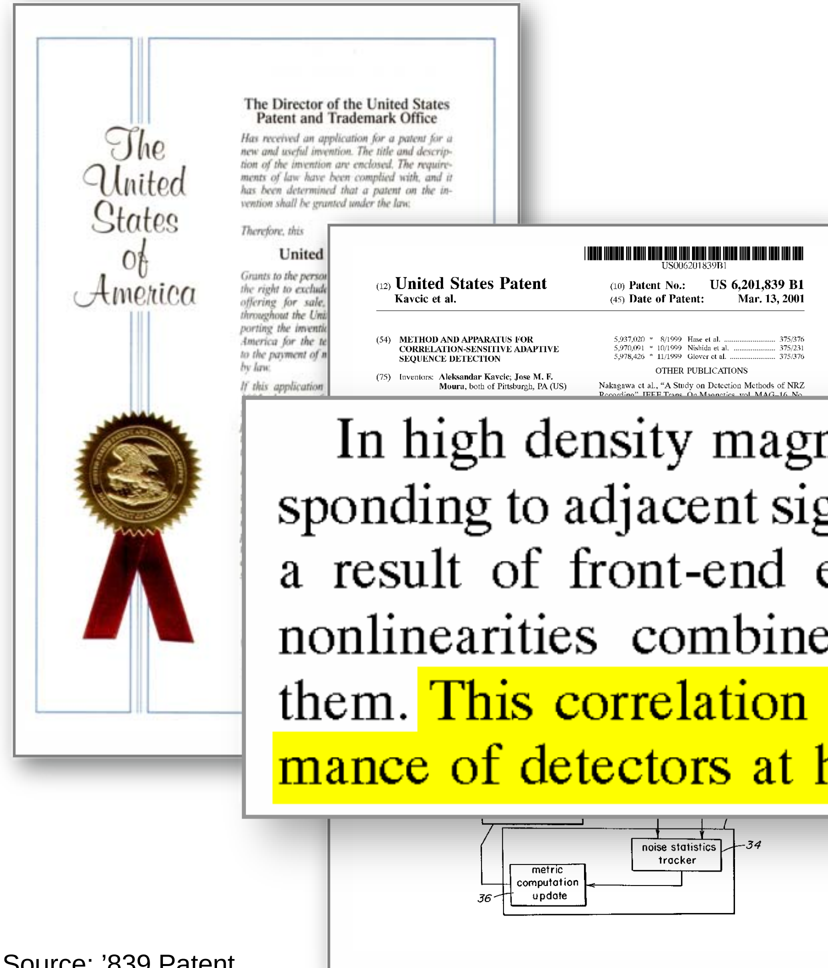
$\boxed{0.51}$

$$BM_i = (\ r_t - \ m_i\ )^2$$

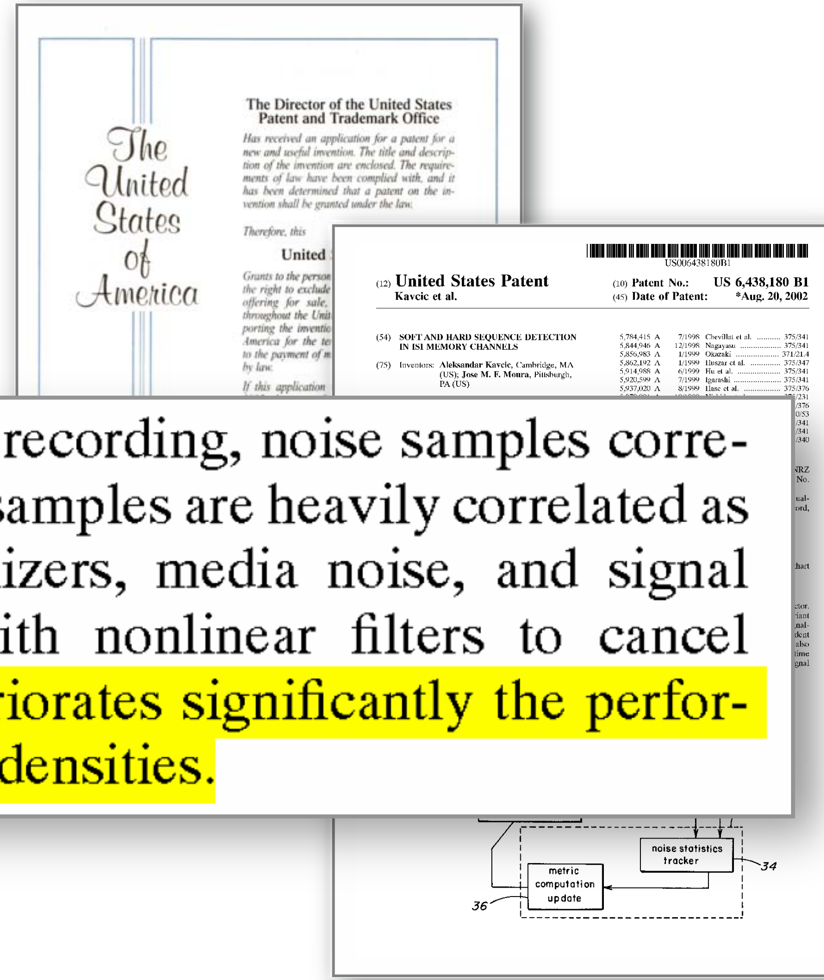
Kavcic-Moura Detector

The Kavcic-Moura Patents

U.S. Patent 6,201,839



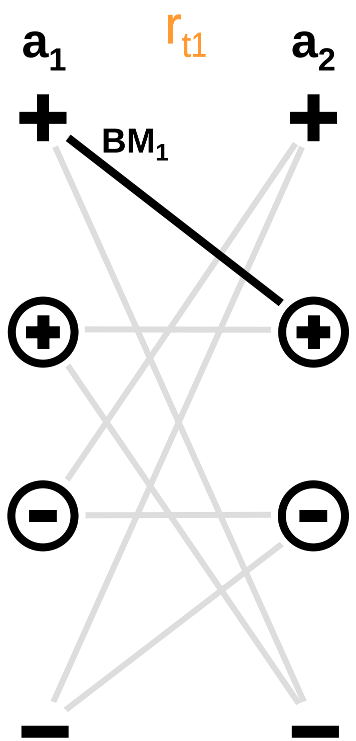
U.S. Patent 6,438,180



In high density magnetic recording, noise samples corresponding to adjacent signal samples are heavily correlated as a result of front-end equalizers, media noise, and signal nonlinearities combined with nonlinear filters to cancel them. This correlation deteriorates significantly the performance of detectors at high densities.

Source: '839 Patent (2:2-7)

Prior Art Branch Metrics



Computing Branch Metric 1 (BM_1)

Prior Art

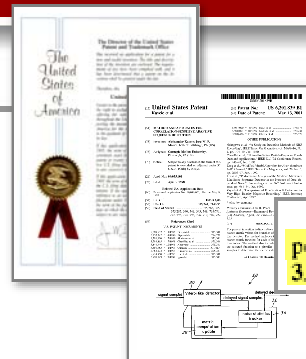
$$BM_1 = (r_{t1} - m_1)^2$$

Kavcic-Moura Branch Metrics

$$M_i = \log \det \frac{C_i}{\det c_i} + N_i^T C_i^{-1} N_i - n_i^T c_i^{-1} n_i \qquad (13)$$

FIG. 3A illustrates a block diagram of a branch metric computation circuit 48 that computes the metric M_i for a branch of a trellis, as in Equation (13). Each branch of the

FIG. 3A is an illustration of a branch metric computation module;



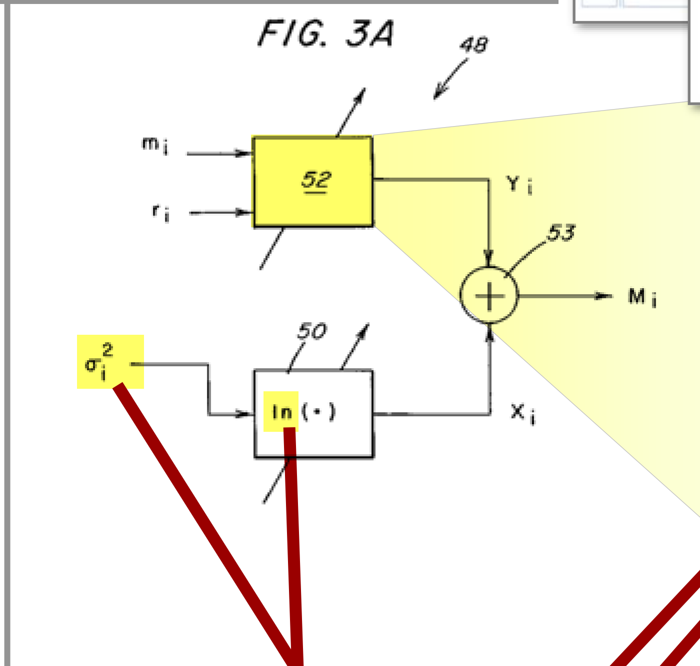
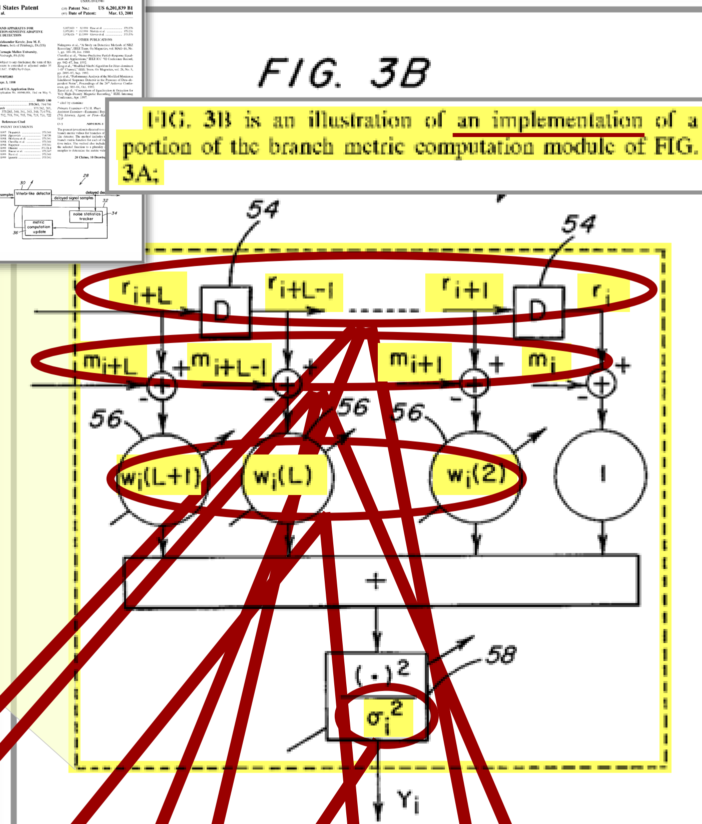
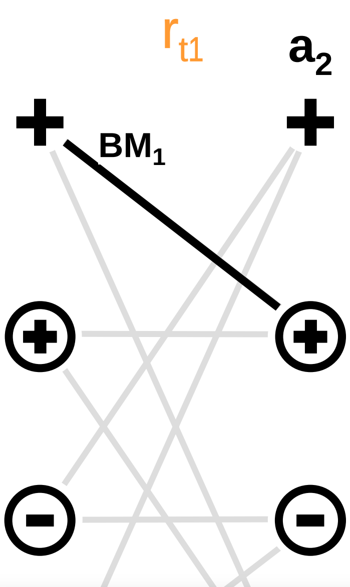


FIG. 3B is an illustration of an implementation of a portion of the branch metric computation module of FIG. 3A;



$$BM_1 = \log \sigma_1^2 + \frac{[(r_{t1}-m_1) + w_{1(2)}\cdot(r_{t2}-m_{1(2)}) + w_{1(3)}\cdot(r_{t3}-m_{1(3)})]^2}{\sigma_1^2}$$

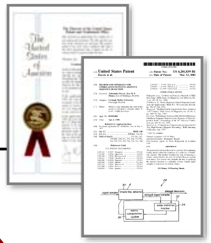
Kavcic-Moura Branch Metrics



Computing Branch Metric 1 (BM_1)

Kavcic-Moura utilizes a novel equation to calculate a more accurate branch metric

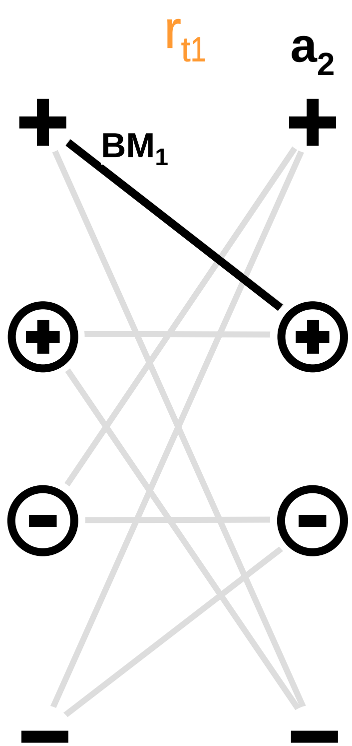
Correlation-sensitive branch metric. In the most general case, the correlation length is L>0. The leading and trailing ISI lengths are K_l and K_t, respectively. The noise is now considered to be both correlated and signal-dependent. Joint



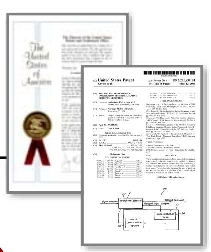
$$BM_1 = \log \sigma_1^2 + \frac{[(r_{t1}-m_1) + w_{1(2)}\cdot(r_{t2}-m_{1(2)}) + w_{1(3)}\cdot(r_{t3}-m_{1(3)})]^2}{\sigma_1^2}$$

Source:
'839 Patent (6:36-39)

Kavcic-Moura Branch Metrics



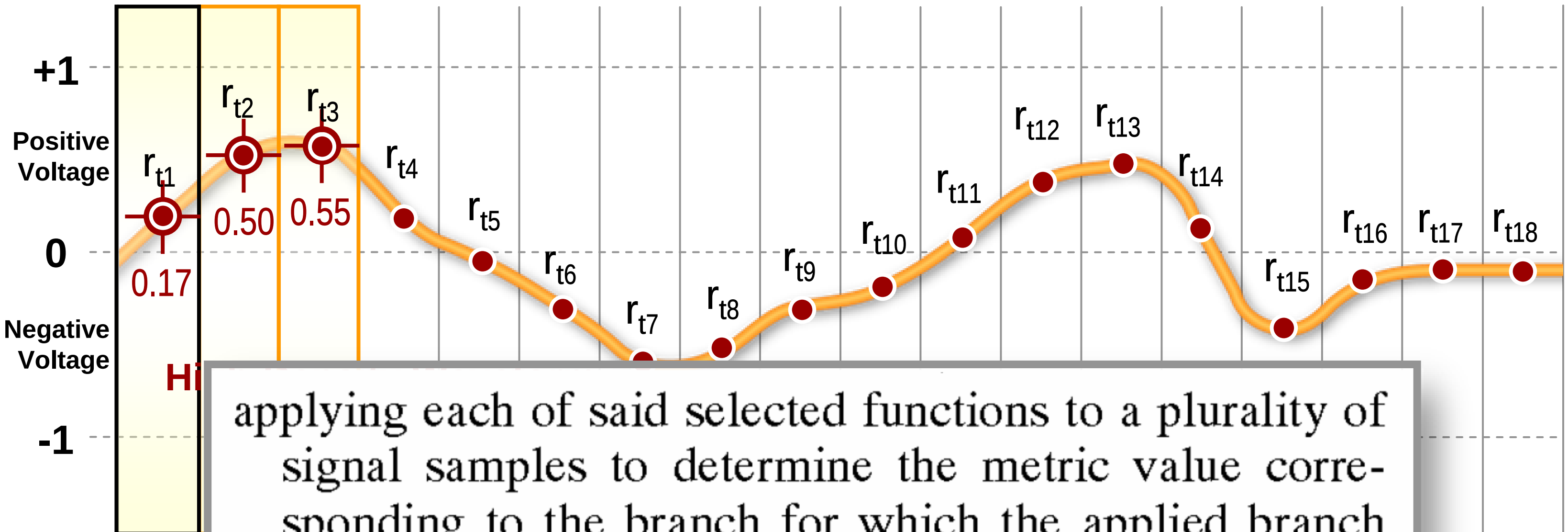
Computing Branch Metric 1 (BM_1)



? ? ?

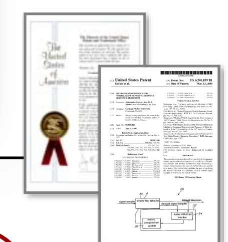
$$BM_1 = \log \sigma_1^2 + \frac{[(r_{t1}-m_1) + w_{1(2)} \cdot (r_{t2}-m_{1(2)}) + w_{1(3)} \cdot (r_{t3}-m_{1(3)})]^2}{\sigma_1^2}$$

Kavcic-Moura Branch Metrics



applying each of said selected functions to a plurality of signal samples to determine the metric value corresponding to the branch for which the applied branch metric function was selected, wherein each sample corresponds to a different sampling time instant.

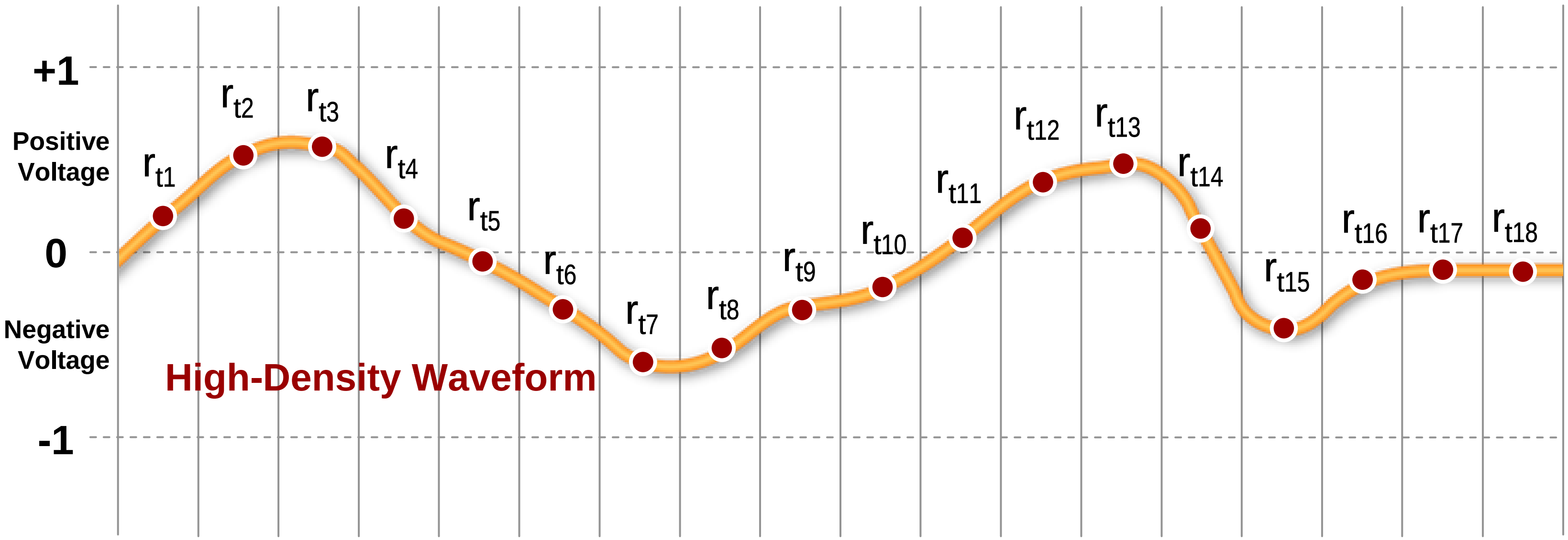
Source:
'839 Patent Claim 1 (13:61-14-2)

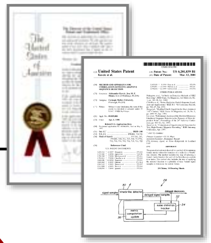


? ? ?

$$BM_1 = \log \sigma_1^2 + \frac{[(r_{t1}-m_1) + w_{1(2)}\cdot(r_{t2}-m_{1(2)}) + w_{1(3)}\cdot(r_{t3}-m_{1(3)})]^2}{\sigma_1^2}$$

Kavcic-Moura Branch Metrics

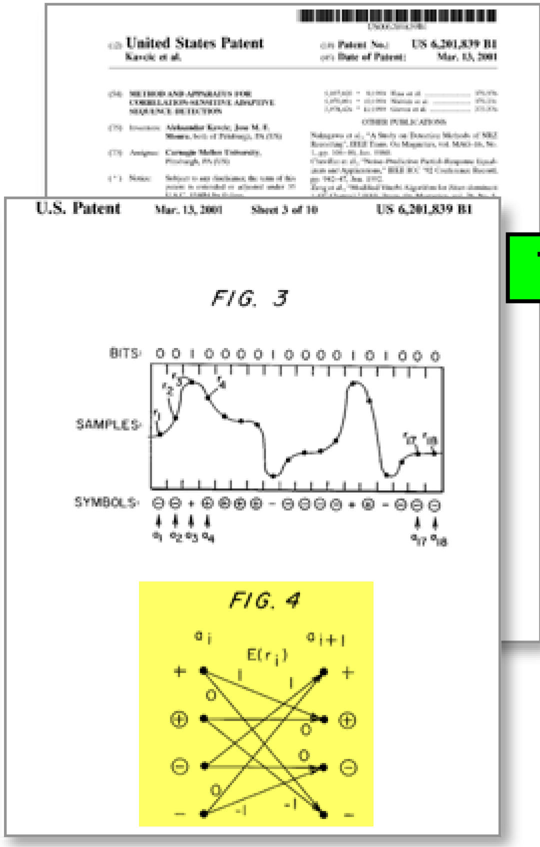




? ? ?

$$BM_1 = \log \sigma_1^2 + \frac{[(r_{t1}-m_1) + w_{1(2)}\cdot(r_{t2}-m_{1(2)}) + w_{1(3)}\cdot(r_{t3}-m_{1(3)})]^2}{\sigma_1^2}$$

The Kavcic-Moura Patents



Target Values